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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS



JULY 1924

SUMMER MEETING NUMBER

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

A friend of Stabilators paid them a sincere compliment the other day when he remarked:

“They work”

And of what value whatsoever is a so-called easy-riding device if it does not do just that?

To hamper a car by equipping it with anything short of that which really does the trick is a hindrance to the car dealer who is anxious that his cars shall compete in today's great race for roadability—he is prevented from recommending more efficient equipment because he cannot well condemn the donated equipment, and remain loyal to his Factory.

JOHN WARREN WATSON COMPANY
Twenty-fourth and Locust Streets
PHILADELPHIA



WATSON
STABILATORS

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XV

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No. 1



Chronicle and Comment

The Summer Meeting Story

A COMPLETE illustrated story of the Summer Meeting at Spring Lake is presented in this issue of THE JOURNAL. The meeting was an unqualified success from all standpoints. Technical papers and discussions were replete with valuable engineering information. The 600 or more members and guests in attendance enjoyed every minute of their stay. Those not fortunate enough to attend will enjoy reading the account starting on the next page.

Where the Meetings of the Society Are Held

FROM 1906 to 1923 the annual meetings of the Society were held at New York City. This year the annual meeting was held very successfully in Detroit. Of 18 semi-annual meetings, 12 have been held in the West, 5 in the East and 1 at Buffalo. One of the meetings held in the East was that at the City of Washington in June, 1917, the location of this being due to war conditions.

The Constitution of the Society provides for the holding of two National meetings a year, the first of these being the Annual Meeting at which officers are elected. Special meetings can be called by the Council at any time. In recent years, as the work of the industry and the Society has expanded and become more varied, more National meetings have been held, with the result that, instead of the two original meetings, the Society now holds seven National meetings each year, in addition to such functions as the Annual Dinner and the Carnival and meetings of National scope in which the Society participates as a sponsor.

In all cases the Meetings Committee and the Council, in deciding upon the place of meetings, makes selections that promise the best attendance and value to the members, in combination with suitable accommodations for the carrying out of such activities as are desired by the members at the different meetings. The boat trips on the Great Lakes had unique charm, but it is very doubtful whether an inland vessel of sufficient size could be chartered to provide what is now required for a Semi-Annual Meeting, with respect particularly to sufficient dining-room accommodation. Moreover, it is impossible to combine in connection with the boat trip the conduct of the sport events that have become customary at the

summer gatherings. For many years the policy has been to select for the Semi-Annual Meeting the location nearest the center of the residence of the members that was considered suitable for the holding of the Meeting. The largest Summer Meeting of the Society that was ever held was that in Dayton in 1918, at which time, it will be recalled, a large exhibit of automotive apparatus for use in war was made. The places decided upon for the National meetings held and scheduled to be held this year are as follows:

Detroit	2	Cleveland	1
New York City	2	Dayton	1
Spring Lake	1		

Riding-Qualities Research

INCREASED comfort for passengers and improved conditions for fragile loads are the definitive aims of any practical study of the riding-qualities problem. It is believed that an analysis of the motions and the forces to which an automobile passenger or other load is subjected should be the first step in such a study, but the fact is often overlooked that such an analysis, however thoroughly made or interestingly presented, has but slight value unless the effects of the motions can be determined with a view to coordinating the motions and the reaction and applying the results to the design of automobiles.

This need for coordination is stressed in a paper on Riding-Qualities Research that appears in this issue of THE JOURNAL, p. 75. Investigators of the problem, it is known, have made many tests with accelerometers and seismographs and have obtained records from which valuable information may be obtained; but the question arises, what do accelerometer or seismograph records mean in terms of riding-comfort? An interesting suggestion for future research involves subjecting a large number of persons to laboratory tests, in which riding conditions could be accurately reproduced with suitable apparatus, and studying the results in close cooperation with physiological and psychological experts. Thus, the effect of well-defined motions or combinations of motions upon the average individual might be determined. The above-mentioned paper is presented with a view to encouraging further consideration and helpful discussion of the riding-qualities problem.

MEETINGS OF THE SOCIETY

SUMMER MEETING IS COMPLETE SUCCESS

Over 600 Members and Guests Enjoy Valuable Meetings and Sports Program

Circulating among the crowd departing from the Summer Meeting and listening to the comments made here and there on the week's proceedings, one could not help arriving at the conclusion that the assembly at Spring Lake from June 24 to 27 had been a complete success. Viewed from any angle, the value of the technical sessions, the papers and the discussions, the porch chair conferences, or the sports and social activities, general approval seemed to be voiced. While it is true that the attendance was smaller than that at the 1923 Summer Meeting, the 600 or more who came to Spring Lake this year made up a representative gathering. Nearly as many companies and institutions were represented as last year, but the slowing-up of business was reflected in the curtailment of expenses on the part of many companies which sent smaller delegations.

Despite the decrease in total registration, the attendance at the technical sessions seemed to be greater than at any of the Summer Meetings of recent years. The whole convention had an air of seriousness about it. All the audiences were unusually attentive. Discussions were active at all times and drew out more than the usual quota of usable information.



BELL-RINGERS LET EVERYONE KNOW WHAT WAS GOING ON AT SPRING LAKE

Judging largely from the attendance, the keenest interest was evidenced in the riding-comfort papers and discussion. The audience at this session numbered 200 or more. While no panacea for rough-riding ills was developed, the session cleared the atmosphere of mystery that has persisted around the riding-quality problem. It is clear that some means must be found to differentiate between that which is psychological discomfort and that which is real or physiological discomfort. Too little fact and too much opinion has been mixed into the question of what makes an easy-riding car. This meeting aimed to place riding-quality mensuration on a tangible basis so that the factors influencing it can be studied and the causes of discomfort removed.

Another session that excited considerable favorable comment was that devoted to air-cleaners. The subject was covered from many angles in the papers and the discussion left the impression that engineers have not generally appreciated the value of these devices as a means of lengthening engine-life. The opinion was expressed by many engineers that air-cleaning devices will appear as standard equipment on many cars before another New York Show has passed.

The attack on the crankcase-oil dilution problem is beginning to bear fruit. Certainly the papers and the discussion in the two dilution sessions indicated that developments are pointing toward an eventual solution of this problem. High cylinder-wall and crankcase temperatures tend to prevent excessive dilution, as was indicated by the Bureau of Standards report and one of the other papers, but other authorities believe that some means of rectifying, cooling or filtering the contaminated oil will be needed.

Several engineers at the meeting predicted that the next engineering attack will be made upon the sliding-gear transmission. This was borne out by the interest taken in the transmission papers and the degree of curiosity evidenced as the members examined and drove the cars fitted with transmissions of unconventional design.

Wheel shimmy and other problems encountered in the introduction of the balloon tire were conspicuous among the topics of informal porch and boardwalk conferences. Little, if anything, was heard about four-wheel brakes. Apparently they are accepted by the majority as an essential feature of the modern automobile and the many real and imaginary problems that were in evidence at last year's Summer Meeting have been either overcome or forgotten. The presence of a "steam-cooled" car prompted many arguments, and remarks were heard here and there about what can be accomplished when anti-knock fuels are generally available.

All sessions, papers and discussions, as well as the sports and entertainment program, are covered fully in the illustrated account of the Summer Meeting that follows. Many of the papers are published in full in this issue of THE JOURNAL.

H. L. HORNING PRESIDENTIAL NOMINEE

Nominating Committee Announces Ticket of Society Officers for 1925

H. L. Horning was nominated to serve as president of the Society for the next administrative year by the Nominating Committee, which was completed and organized at the Spring Lake meeting. The committee reported the following other consenting nominees for the elective officers next falling

MEETINGS OF THE SOCIETY

3



AMATEUR PHOTOGRAPHERS IN CONFERENCE

H. L. Horning (Left) and David Beecroft (Right) Talking Things Over

vacant under the constitution, that is, after the 1925 Annual Meeting of the Society.

First Vice-President—T. J. Little, Jr.

Second Vice-President, representing motor-car engineering—H. D. Church

Second Vice-President, representing tractor engineering—O. B. Zimmerman.

Second Vice-President, representing marine engineering—C. A. Carlson

Second Vice-President, representing aeronautic engineering—P. G. Zimmerman

Second Vice-President, representing stationary internal-combustion engineering—C. F. Scott

Councilors (to serve during 1925 and 1926)—C. H. Foster, O. M. Burkhardt and E. P. Warner

Treasurer—C. B. Whittelsey

The members of the 1924 Council who will hold over during 1925 are H. M. Crane as past-president and Councilors A. K. Brumbaugh, J. H. Hunt and M. P. Rumney.

The personnel of the Nominating Committee which organized and reported at Spring Lake last month was: H. L. Pope, chairman, member-at-large; J. W. White, Buffalo Section; R. E. Wilson, Chicago Section; O. A. Parker, Cleveland Section; F. F. Chandler, Indiana Section; A. C. Bergmann, Metropolitan Section; S. F. Briggs, Milwaukee Section; R. E. Northway, New England Section; F. M. Germane, Pennsylvania Section; A. W. S. Herrington, Washington Section; H. C. Dickinson and John Younger, members-at-large.

This was the annual Nominating Committee, provided for by the Society's Constitution, under which 20 or more members entitled to vote may constitute themselves a special Nominating Committee, with the same power as the annual Nominating Committee. The By-Laws of the Society provide that a special Nominating Committee, if organized, shall on or before Nov. 15 present to the Secretary of the Society the names of the candidates nominated by it for the elective offices next falling vacant, together with the written consent of each.

BUSINESS SESSION

Action on Standards and Proposal of Constitutional Amendments

The 1924 semi-annual business session of the Society was convened on Tuesday evening. President Crane read the resolution that the Council had passed during the day deploring the demise of Mr. Swetland, and the members stood for 1

min. in silent tribute to this loved founder member who supported the Society ardently and effectually for many years.

As provided by the Constitution, three members at large of the 1924 Nominating Committee of the Society were elected. The Members named were H. L. Pope, H. C. Dickinson and John Younger.

The business session was then adjourned to meet on Friday morning, to consider the action of the Standards Committee at the Summer Meeting, as well as new business.

At the adjourned session the Members approved, for submission to letter ballot of the voting Members of the Society, the recommendations as to standards and recommended practices presented by the Standards Committee Divisions making reports, as accepted by the whole Committee, except in the case of the recommendations of dimensions for compression-type tube-fittings. The Council, after some study subsequent to the Standards Committee meeting, had directed that the last-named recommendation be held in abeyance in view of some unsettled matters in connection with patents on the type of fitting involved.

FLEET OPERATORS AND SERVICE-MEN

R. E. Plimpton proposed that the first sentence of section C2 of the Constitution of the Society be amended to read as follows:

The object of the Society is to promote the Arts and Sciences and Standards and Engineering Practices connected with the design, [and] construction and utilization of [automobiles] *automotive apparatus*, all forms of self-propelled or mechanically propelled mediums for the transportation of passengers or freight, and internal-combustion prime-movers.

The words printed above in brackets are those which under this amendment would be stricken out of the Constitution and the italicized words are those which would be inserted.

Mr. Plimpton proposed also that that part of section C8 of the Constitution which now reads—

... or to take the responsible charge of automotive engineering work; or to impart technical instruction in the design and construction of automotive apparatus;

be amended to read

... or to take responsible charge of automotive engineering work, *including operation or maintenance*; or to impart technical instruction in the design, construction and utilization of automotive apparatus; . . .

The words that appear above in italics are those that are proposed to be added.

The two sections of the Constitution mentioned above set forth respectively the object of the Society and the qualifications for Member grade.



NOT A NEW FORM OF DEVOTION, MERELY THE STANDING BROAD JUMP

Mr. Plimpton's purpose in proposing the amendment, which was in substance the draft prepared by the Society Committee on the Grading of Applicants Approved for Membership, was to clarify the wording of the Constitution with regard to the status of men who are engaged in the operation of automotive-vehicle fleets and also that of service-men, so far as their being welcome as members of the Society and the grades of membership to which they are entitled are concerned.

The proposal of these amendments was seconded by Cornelius T. Myers. The Constitution of the Society cannot be amended at one meeting but provides that the Members be informed what is proposed at a given meeting and that this be considered at the next subsequent meeting, the subsequent meeting in this case being the 1925 business session of the Society to be held next January.

DESIGNATION OF ANNUAL SECTIONS COMMITTEE

J. H. Hunt proposed that section C45 of the Constitution be amended as follows:

Delete the words "Sections Committee, consisting of five members."

Insert the following before the last full paragraph of the present section 45:

There shall be also an administrative committee of the Society called the Sections Committee. This committee, the members of which shall serve for 1 year, during the administrative year, shall consist of one member of the Society to be elected from and by each Section of the Society each year prior to the Annual Meeting of the Society, and three members of the Society who shall be appointed by the President within 30 days after he takes office. The President shall name the Chairman of the Committee.

This proposal, which was duly seconded, has the same status that the constitutional amendments mentioned first above have. The purpose is to provide that the Sections Committee of the Society shall be designated each year in a manner analogous to that provided in the Society constitution in the case of the Nominating Committee of the Society, except that the "members at large" of the Sections Committee would be named by the President of the Society and he would also select the Chairman of the Committee. The draft of this proposed amendment has been approved by the Constitution Committee of the Society, of which W. A. Brush is chairman. Mr. Hunt is chairman of the present Sections Committee.

PERPLEXING PHASES OF DILUTION

Analyses Made of Many of Its Detrimental Effects and Remedies Suggested

Injury to engine parts caused by dilution of the crankcase oil is a problem of increasing importance. Due to the demand for engines of high power, many car engines are oversize for normal or nominal requirements; hence, for ordinary usage, they run at too low a percentage of their power capacity and run too cool, a condition that causes dilution to a much greater extent than is desirable. These statements were made by Chairman T. J. Little, Jr., in the course of his opening remarks at the session held on the morning of June 25, during which the threshing-out of the general subject of dilution was begun and subsequent to which a second session was convened on the evening of the same day. Chairman Little said further that many devices have been and are being developed, some with a view toward preventing dilution and others with the idea of reducing the amount of dilution. He mentioned also the effects of using different grades of fuel; the sulphur content in fuel, its formation of acid in the presence of water of condensation and its subsequent corrosive action; and other subjects that were to be discussed.



C. M. LARSON



NEIL MACCOULL

C. M. Larson's paper on the above subject included comment on the varied car-mileages recommended as determinants of when an engine crankcase should be drained. He characterized them as rule-of-thumb methods that may result in harm to the engine in some cases and in wastage of oil in others. He said that automotive research departments have compiled sufficient data so that fundamental curves can be drawn and presented diagrams showing percentages of dilution with relation to horsepower, distance run, increased piston-clearance, grades of fuel used, summer and winter operation and oil viscosity.

To the end that "crankcase service" may be made more practical, research was undertaken and, after repeated checking of used samples and charting of gravity change with percentage of dilution, an instrument termed a Dilut-O-Meter and another called a Visgag were developed. These were illustrated and described. The former indicates the condition of the oil; the latter has a simplified scale to enable the motorist to follow the manufacturer's recommendation as to crankcase drainage. Such devices, it was said, allow the motorist to determine when his engine-lubricant is becoming badly contaminated and too light in body, so that it does not provide a proper piston-seal. They also were said to indicate whether the fuel mixture is correct or incorrect, whether the choke is being used too freely, and whether the grade of fuel being burned accentuates dilution.

Early in the discussion following the paper, J. A. C. Warner, assistant research manager of the Society, reviewed the results of a questionnaire circulated among manufacturers to obtain their views regarding dilution. Some of the outstanding points made in the replies were that an educational campaign should be conducted to discourage drivers from making excessive use of the choke, that good distribution of the fuel to the engine cylinders is essential and that about 15 per cent of dilution constitutes the danger-line for oil, it then being desirable to change it.

Wide differences of opinion were expressed regarding the frequency at which the oil should be changed, or the mileage that it is reasonable to expect from one filling of oil. This varied from 300 to 1000 miles for winter operation and from 500 to 2500 miles for summer. Regarding the suggestions made in these replies as to what phases of improvement would be most beneficial, these included recommendations for the use of thermostats, oil-cleaners, air-cleaners and oil-renovators. It was mentioned also that the dilution problem is twofold and has to do with both dilution and contamination of the oil.

Chairman Little remarked that crankcase drainage is "up to the engineer" in that means must be provided whereby the motorist can determine the actual condition of the oil, and that drainage be made an easy operation. R. W. A. Brewer stated that the temperature at which the oil does its work and the foreign substances and the mineral acids in the oil are of greatest importance in all dilution-problem

considerations. Further, that engineers want to know what happens at a crankcase temperature of, say, 80 deg. fahr. above atmospheric temperature.

CONSUMPTION AND DILUTION OF ENGINE OIL

This subject was ably presented by Neil MacCoull. His paper is printed in full on p. 93 of this issue of THE JOURNAL. He emphasized that the paper is only a progress report and that further work is being prosecuted. Among the statements he made in the course of the discussion, in reply to written questions, were the following: The lower the viscosity of the oil is, the greater in amount the dilution becomes; warm jacket-water is desirable; the effects of sludge formation are outside the field of this investigation, and the oil-pan should be heated. He said that all tests except the last referred to in the paper were made at a constant engine-speed and cited one instance within his knowledge in which the amount of dilution was greater than the amount of oil consumption. In his concluding remarks, he read a summary of replies made to queries regarding the most desirable oil-pump size which had been submitted to numerous manufacturers. The capacities stated in these replies varied from 0.5 to 10.0 cu. in., the average being 1.8 cu. in. per revolution per 1000 cu. in. of piston displacement.

O. M. Burkhardt mentioned the detrimental effects of water and of foreign substances in the oil. J. O. Eisinger, of the Bureau of Standards, remarked on the influence oil-circulation has on the degree of dilution and said that contamination of the oil constitutes the greater problem. He stated also that the Bureau's tests bear out, in general, the findings of Mr. MacCoull's paper. R. W. A. Brewer reported that he had obtained beneficial results from agitating the oil while heat is being applied and from increasing the oil circulation. F. G. Clark, of the Sinclair Refining Co., reported briefly on tests that his company had made.

O. C. Berry referred to the necessity for temperature control of the intake-manifold, since dilution is greatest on starting an engine. He instanced cars that required 2 or 3 miles of running before economical conditions of operation can be established and other cars that can attain such conditions in about 0.1 mile. He advocated an intake-manifold having a very hot hot-spot of a not too great area above the carbureter. As to the needed temperature of the metal to vaporize the fuel, this is accomplished at about 400 deg. fahr.; but the temperature can then be raised, say, to 1000 deg. fahr. without a great increase in the amount of fuel evaporated.

WATER IN CRANKCASE OILS

This subject was treated at length by A. L. Clayden, the complete text of the paper being printed in this issue of THE JOURNAL, beginning on p. 47. He remarked that the data contained therein check remarkably well with the results obtained by Mr. MacCoull. He said also that the points for the curve shown in Fig. 3 of his paper, obtained from the test data, were remarkably close to the actual straight line.

Written questions were submitted as a basis for discussion. With regard to room temperature and the degree of humidity during the tests, Mr. Clayden said that these were extremely variable but that the humidity had little or no effect. Practically no condensation from the air was experienced. If the temperature of cooling water is above 100 deg. fahr., the water will be eliminated. Agitation was specified as being an important factor, and it was admitted that the oil must be hot when it reaches the bearings.

F. E. Moskovics read a report of a test made in which castor oil was blended with a highly refined mineral oil, the theory being to reduce dilution by making use of the great adhesive property that castor oil possesses for hot metal and its repellant action toward hydrocarbons. The tendency would thus be to prevent the gasoline particles from absorbing the oil-film on the cylinder wall, thus correcting the most prolific cause of crankcase-oil dilution as well as reducing the principal cause of contamination. The test

was made with a car driven continuously for about 100 hr. in dense city-traffic. The oil showed very little deterioration other than slight dilution with gasoline, which was said to be compensated for by the gradual thickening of the castor-oil content.

Dr. H. C. Dickinson stated his satisfaction at finding how well all this experimental work tied-in with the elemental theory. He mentioned the great difficulty of obtaining the actual temperature of the cylinder walls and, instancing how a pitcher of ice water shows dry above the dew-point and wet below it, suggested the possibility of determining cylinder-wall temperatures in some such manner. He referred to the complexity of fuel mixtures and suggested the use of so-called equilibrium mixtures that act as does some single substance. Further, he suggested that Mr. Clayden make tests with different fuels in the same engine.

B. B. Bachman commented upon the extreme difficulty of thinking coherently on the subject of oil contamination which, because of changes in the character of the fuel, he believes is the important problem. He wanted to have the different variables evaluated and thought this might lead to radical methods of cure and away from the present tendency toward a multiplicity of devices. He suggested, in regard to the deposition of water, the use of the engine load-factor as a variable in testing. He cited data from road-tests of trucks in regular service for his company, trucks that had not been drained for some time and service that included 150-mile runs, 45-min. stops with the engine idling and the like, as evidence that the amount of water deposition varies from zero to being a small quantity only.

CORROSION IN AUTOMOTIVE ENGINES

Due to the enforced absence of the author, H. C. Mougey, of the General Motors Research Corporation, Dayton, this paper was presented by J. H. Hunt of the same company. It is expected that the paper will be published in an early issue of THE JOURNAL, but some of its important features are included herewith.

Corrosion occurs when water is present, and the products of combustion that "blow-by" can condense. Two methods for preventing corrosion exist, that of eliminating dilution and that of determining what constituents of dilution cause corrosion. The three theories regarding corrosion are termed the acid, the oxide and the electrolytic. When gasoline is burned in an internal-combustion engine, the sulphur content and the water vapor form sulphuric acid, and this causes pitting of the metal parts. In various territories it was found that the fuel in use had a high sulphur-content in many instances, and the paper reports the results of tests made of engines in actual service, with and without the use of devices for the elimination of water. Of the latter, some showed water, nil to 0.5 per cent; total dilution, 14 to 22 per cent; iron oxide, 1.40 to 1.64 per cent. When



LOOKS LIKE ANOTHER WAR
Trapshooters in Quest of Clay Pigeons

water was not present, only about 1/20 the amount of iron oxide existed.

In the discussion that followed, Thomas Midgley, Jr., made remarks on the failure of engine parts due to corrosion caused by sulphur and mentioned that the lamp test-method is not satisfactory when used with fuel containing carbon bisulphide. Neil MacCoull said it is needless to worry about the sulphur content of fuel if water is kept out. He cited Diesel-engined ships in which the engines are started on kerosene but said that the fuel used after starting had a 3-per cent sulphur content. A. L. Clayden advocated the development of some simple method of determining the amount of crankcase-oil dilution and suggested that the Standards Department of the Society make an effort to accomplish this result.

W. L. Dempsey, of St. Louis, exhibited lantern-slide views of a gas-engine embodying unusual features and described them briefly. The feature of "supercharging" the cylinder was said to improve the entire functioning of the engine, inclusive of greatly reducing dilution. First, an over-rich but explosive mixture is admitted to the cylinder through the normal intake-valve. Second, by using an auxiliary intake-valve, a supply of pure air is admitted to the cylinder at the end of the suction stroke, the quantity of air being automatically varied according to the position of the throttle so that an approximately equal amount of compressible gas is introduced into the cylinder at each induction stroke, irrespective of the position of the throttle. This fills the vacuum space in the cylinder with pure air more effectively than does the charge taken in through the carbureter. Thus, the charge is not only of greater weight and density, but the volume of compressible gas is practically the same at part throttle as at full throttle, making the amount of compression practically the same at all throttle settings.

RECTIFICATION OF DILUTED CRANKCASE-OIL

Two papers were presented at the evening session, the one bearing the foregoing title being the first. It was read by the author, R. L. Skinner, and the full text will be found in this issue of THE JOURNAL, beginning on p. 51.

Preceding its delivery, Chairman J. H. Hunt said in his opening remarks that complaints from owners regarding failures of engine parts too soon after purchase had been made in many instances and that some of this trouble had been traced back to dilution as a cause. The usual method thus far has been to drain the crankcase; but, if the owner does this as frequently as recommended, the method becomes too costly and, if he neglects drainage, he suffers because of the resultant increased repair-bills. Another method is that of attempting to maintain the oil in its original condition and Mr. Hunt stated it to be the special subject for consideration at this session. To make possible his presence at another session that was convened at this time, Mr. Hunt yielded the chair to R. E. Wilson, member of the research

council of the Standard Oil Co., Whiting, Ind., who conducted the meeting thereafter.

Mr. Skinner said that there is no danger of taking too much oil off the pistons. Even when a high-speed vacuum pump was used to draw off intentionally a larger amount of oil than the rectifying device, no trouble was experienced due to insufficient lubrication. The device draws off less oil as the engine speed increases. O. M. Burkhardt's query regarding sludge that might cause stoppage of the small orifices brought the answer that no such effect had been experienced in tests of the device made to date. The effect of the system on starting from cold was said to be negligible provided a proper oil seal existed around the pistons.

W. G. Wall stated his belief that an oil rectifier is an essential, especially on the high-speed engines of today; air-cleaners are needed also but are not so important as rectifiers, which he believes may be necessary as dilution preventives.

L. M. Stellmann said that the Franklin company had tested the system described by Mr. Skinner for 1½ years with success. The rings remained free and there was about one-third the wear when using the device compared with the wear when not using it. In a test across this continent and back with a car equipped with the device, the maximum wear in 10,000 miles was 0.0015 in.

COOPERATIVE FUEL-RESEARCH PROGRESS-REPORT

The report, presented by J. O. Eisinger, is printed in this issue of THE JOURNAL, beginning on p. 69. In opening the discussion Chairman R. E. Wilson remarked on how well its data check with the other data presented in these sessions, and this was also commented upon favorably by others.

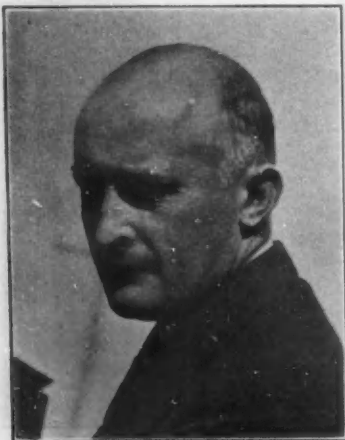
F. E. Moskovics called attention to the advantages resulting from atomizing the fuel and spoke of the supercharger used on the Duesenberg racing-car as being more properly termed an atomizer. F. S. Duesenberg expressed the opinion that the supercharger will reduce dilution and said he is surprised at the good carburetion it gives. After the Indianapolis race, six of the exhaust-valves on his racing car showed white and only two were black. President H. M. Crane said that the engineers of the industry now possess a fine set of tools with which to work out the problems of dilution, and expects that these tools will be used effectively.

Referring to the bomb experiments described by Mr. Eisinger, these were cited by W. L. Dempsey as indicative of the benefit that can be derived from introducing an ample supply of air to an engine cylinder. Asked by O. C. Berry for an opinion as to the advisability of using a thermostat to control jacket-water temperature, Mr. Eisinger replied that it would have a marked effect toward reducing dilution.

Queried by Chairman Wilson as to whether heating of the intake-air raises the jacket-water temperature, Dr. H. C. Dickinson answered that the temperature of the intake-air does not affect dilution materially. He said that, for the most part, the oil-film on the cylinder wall is in such intimate contact with the metal that it can take-up heat readily. Further, that the percentage of oil which goes down past the rings is determined mainly by the temperature of the cylinder walls.

References were made by T. J. Little, Jr., and by C. P. Grimes to the great amount of dilution that occurs during the warming-up period and some instances of this were cited. President Crane asked what happens to the oil-film in the cylinder to cause dilution to progress in a manner contrary to expectation and, in reply, Chairman Wilson said he believed the reciprocating action of the piston causes it to act as a mixing device.

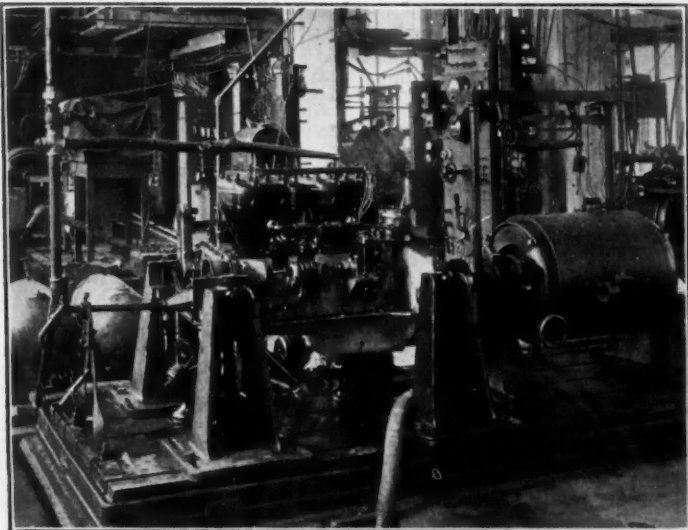
C. P. Grimes referred to the lubrication of the piston during the warming-up period. He said that an engine having an aluminum piston-head was placed in a cold box where the temperature was 20 deg. below zero fahr. For the first partial turn by hand it was free but then became too stiff to turn. Oil was then squirted in through the spark-plug hole and this immediately caused the engine to become free again.



R. L. SKINNER



J. O. EISINGER



APPARATUS USED BY THE BUREAU OF STANDARDS IN RUNNING ITS DILUTION TESTS

Following the discussion a demonstration was made of the bomb experiments described in Mr. Eisinger's paper, and this was observed with great interest by as many of those present as could crowd around the apparatus. Both the morning and the evening sessions devoted to dilution were largely attended, and great interest was manifest in all the data presented.

RIDING-QUALITIES RESEARCH

A Very Complicated Problem Viewed from Many Different Angles

What constitutes riding-comfort? What are the factors or qualities that help to increase comfort? How may these factors be measured? How may the results of such measurements be applied to insure greater riding-comfort? To what extent is a passenger's reaction to the motion of a car physiological and to what extent is it psychological? What has already been done along the lines indicated above and what is the best method of attacking what remains to be done? These are some of the questions that were considered in the papers and the discussion at the Riding-Comfort Session of the Summer Meeting, which convened in the ballroom of the Monmouth Hotel at Spring Lake, N. J., on Tuesday, June 24, at 2:30 p. m.

The keynote to the situation was sounded by President H. M. Crane, the chairman of the session, in his introductory remarks in which he stressed the complication of the study, due to the fact that no two people ever want to use a car in the same way. Thus opinions vary as to what riding-comfort actually is, so that an enumeration of the factors that contribute to riding-comfort is far from a simple matter. Another difficulty pointed out by Chairman Crane is the lack of a good yardstick for measuring the factors or qualities that must be considered in an investigation of the riding-comfort problem.

SPRING-SUSPENSION DISCUSSED

Spring design as related to riding comfort was discussed in a paper by S. P. Hess, assistant manager of the spring department, Detroit Steel Products Co. The paper is presented on p. 82 of this issue of *THE JOURNAL*, only a very brief summary of it being included here. Spring-suspension is the basis of riding-comfort in passenger cars which should be so designed and so sprung as to effect the transportation of a passenger in such a manner that the trip is a pleasure and not a hardship. The human or psychological element must be considered, as what is objectionable to one person

may not be so to another. The three chief types of motion, horizontal, vertical and side or swaying, must be analyzed, and attention must be directed toward reducing their magnitude. Relative to pitching motion, emphasis was laid on the desirability of reducing this type of motion by the use of a front spring having a high period, and the question of spring periodicity was discussed, together with the flexibility values that should bring about satisfactory riding conditions. With regard to leaf springs, the point was brought out that springs should not be lubricated between the leaves unless some form of damping device is used. To secure the best results from chassis spring-suspension, each design of car must receive separate study, because the type of spring that would secure greater riding-comfort on one type of car might have a different effect when used on another type. Close cooperation is needed between the spring engineer and the car designer.

Characterizing Mr. Hess' paper as the concentrated information obtained from many years of actual experience of putting springs on automobiles, Chairman Crane opened the discussion by disagreeing as to the front-spring period allowed, stating as his opinion that a very much better riding car would be obtained with front springs having a period as low as 100, provided that some form of rebound check be used to prevent excessive plunging of the car under certain conditions. Mr. Crane called attention to the great difference in the weight of the springs compared for period of vibration and questioned what would be the result of an attempt to obtain increased friction by having more leaves, the total weight of the spring remaining the same.

W. C. Keys wished to amplify Mr. Hess' statement that each design of car requires separate study as to spring-suspension, by saying that each body model for each car requires separate study. Mr. Keys commented on the utility of leaf springs which, he believes, will be a permanent part of the automobile.

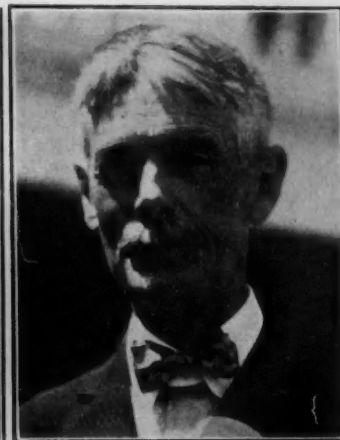
The use of many leaves, tapered, with rounded ends, was recommended by T. J. Little, Jr., who said that where many leaves are used, the inter-leaf friction is increased and the insulation to shock is increased, because less shock can be transmitted through the many breaks and oil-films between the leaves.

Otto M. Burkhardt suggested as a profitable question for study the influence of inter-leaf friction upon the period of a spring, and expressed his opinion that high inter-leaf friction is not advantageous from the viewpoint of riding-comfort.

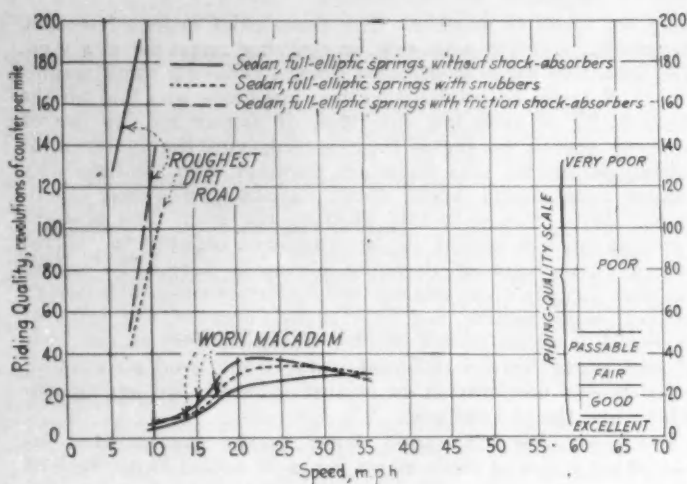
Relative to spring friction, F. C. Mock stated that friction changes the period so much as to render impossible the co-ordination of the period and the initial deflections according to the formulas given by Mr. Hess. Mr. Mock expressed the opinion that friction would be advantageous sometimes and the reverse at other times and suggested the desirability of a more complete analysis of basic factors.



S. P. HESS



PRESIDENT H. M. CRANE



RIDING-QUALITY DIAGRAMS

These Curves Are Plotted from the Records of the Integrating Seismograph Described in the Paper by Messrs. Lockwood and Kimball

SENSITIVITY OF THE HUMAN MECHANISM

Dr. H. C. Dickinson expressed interest in the question as to the sort of motion to which the human system is sensitive and described a type of vibrating machine, devised for the purpose of ascertaining some facts in that connection. The machine had a vibrating platform, with an amplitude of anything up to 0.03 or 0.04 in. and a period of anything from 200 or 300 to 2000 or 3000 per min. It was learned that an amplitude of 0.001 in. at a period of vibration of approximately 500 per min. is distinctly disagreeable; thus, the human mechanism is sensitive to vibrations of amplitude as slight as 0.001 in. Chairman Crane emphasized the importance of this phase of the work, stating that more study should be directed toward ascertaining what qualities in riding are likely to produce irritation in human beings. Another topic needing investigation is whether damping should be put in the spring itself or provided by some exterior device.

Mr. Little referred to his previous remark in which he had expressed a preference for many leaves and stated that he did not mean thereby to increase the inter-leaf friction. It was his idea that the leaves should be well lubricated and that some auxiliary means for restraining their action should be provided. The device to restrain the rebound should operate, however, only after a certain amount of deflection has taken place. Mr. Little advocated using shock-absorbers on rough roads but not on good roads.

The opinion of L. B. Kimball relative to inter-leaf friction is that friction is unnecessary on smooth roads, but that on rough roads it is desirable.



E. H. LOCKWOOD



L. B. KIMBALL

F. P. Herman described some experimental work that had been conducted in an effort to learn more about spring friction.

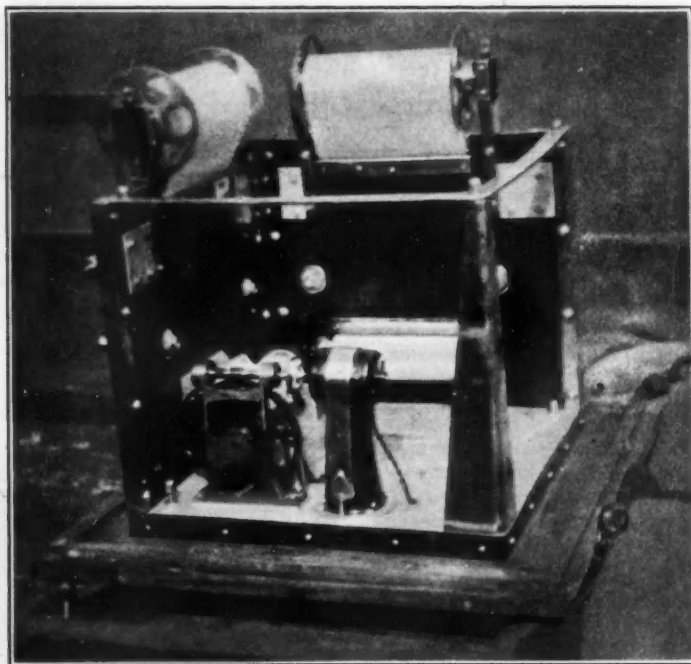
J. A. Anglada raised the question as to the advisability of considering helical springs and shock-absorbers as a means for very definitely separating the effect of spring deflection and the effect of friction.

TWO METHODS OF MEASUREMENT

The second paper of the session was presented by Prof. E. H. Lockwood under the title, A Riding-Quality Indicator. This paper, of which L. B. Kimball is the coauthor, is printed in this issue of THE JOURNAL on p. 40 and for that reason an account of the instrument, an integrating seismograph, described therein, is not needed at this point. The instrument automatically sums up the vertical displacements of a suspended weight that is mounted on a case carried on the vehicle under test. The frequency and the magnitude of the impulses encountered affect the readings.

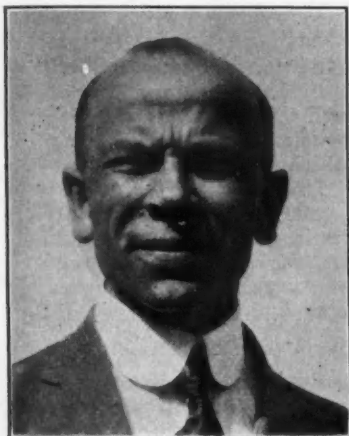
Another device for measuring motion was described and illustrated by Prof. E. P. Warner. Electric lights were mounted on the body and the axle and other parts of a car, including the shoulder of a passenger, and the car was run past a camera, so that a line was traced by each light, showing the motion, the amplitude of the motion and the period of the motion of the several parts of the car. It will be understood that the traces produced by this method are curves of vertical displacement versus time. They may be analyzed by various means to give the vertical accelerations corresponding to the displacements. The scale of displacements can be determined from the known height of an obstacle in the road whereas the time scale is readily ascertained from the known speed of the vehicle and the distance travelled.

Professor Warner stressed the desirability in riding-comfort study of making two different types of analysis. One type



THIS SEISMOGRAPH IS CAPABLE OF RECORDING MOTIONS IN TWO DIRECTIONS AT RIGHT ANGLES TO EACH OTHER BY THE USE OF TWO INERTIA ELEMENTS

would employ a method similar to the one just described by him, consisting of an actual study of the motion of the car and of the body and the long-period motions that are transmitted from the road surface; the other type would employ an instrument such as Professor Lockwood's, designed to give primarily the effects of very short-period motions, most of them probably originating within the sprung portion of the car.



OTTO M. BURKHARDT



JOHN A. C. WARNER

An instrument for measuring the irregularities in the road surface was mentioned by Herbert Chase, who thought it might be conveniently used in connection with Professor Lockwood's instrument, the one supplementing the other.

The following were mentioned and briefly discussed by W. C. Keys as elements that may be readily varied to affect the riding-quality of a car: tires, springs, the condition under which springs operate, rebound control and cushion springs. Concerning the methods of measuring riding-quality factors, presented by Professor Lockwood and Professor Warner, Mr. Keys expressed his opinion that the latter method is the more complete, as the former does not show a real record of what happens to the passenger during a given test.

Instruments incorporating the pedometer principle were described by J. F. Palmer and J. J. McElroy, and their applicability to the riding-qualities investigation was discussed. Mr. McElroy was of the opinion that riding comfort cannot be measured with one instrument. A better plan would be a combination of two or three devices, the results being checked up with graphic recording devices, so that the movements of the axle would be measured simultaneously with the vibrations in the body.

THE PROBLEM SUMMED UP

In a paper entitled Riding-Qualities Research, which is printed on p. 75 of this issue of THE JOURNAL, J. A. C. Warner, assistant manager of the Society's research department, analyzed the types of motion to which an automobile passenger is subjected, described instruments that have been designed and methods that have been used for measuring the factors that are believed to bear most directly on riding-comfort and briefly outlined a suggested plan for future research.

The point was emphasized that the records made by measuring instruments would need to be considered in terms of riding-comfort, and it was believed that the proper coordination would be achieved by studying test results in close cooperation with physiologists and psychologists.

J. E. Hale contributed to the discussion by pertinent remarks concerning the relation of balloon tires to riding comfort. A chronograph was described that was used in investigating front-wheel shimmy.

In a written discussion, B. Liebowitz expressed the opinion that acceleration is of first importance among the factors that influence riding-qualities. He pointed out some of the difficulties encountered in the problem of instrumentation and indicated the type of design that in his opinion would be most successful.

The Riding-Qualities Session was well attended, and it is felt that Chairman Crane voiced the opinion of those present when he emphasized the importance of the question under consideration and expressed his hope and belief that the session would be a starting-point that would lead to future sessions devoted to this topic.

TRANSMISSION SESSION

Methods of Torque Conversion Discussed; Numerous Transmissions Described

Efficient operation, ease of control, simplicity of design and ability to withstand abuse were mentioned by Prof. V. M. Nickelsen, University of Michigan, as being among the requirements of a good transmission. His paper as presented at the Transmission Session will, it is expected, appear in an early issue of THE JOURNAL.

TRANSMISSION EFFICIENCIES

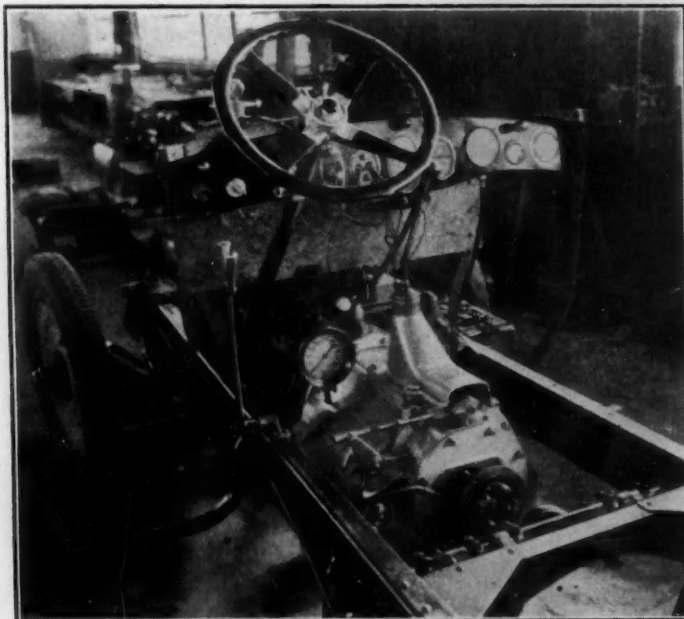
The function of a transmission is to increase the torque of the engine to such an extent that the car will perform well in starting from rest, in accelerating or in hill climbing. Unlike the steam engine or electric motor the gasoline engine requires considerable initial speed in order that the load may be taken properly. The greater reduction between the engine and the rear wheels makes more torque available for car flexibility.

In his analysis of the various types of transmission Professor Nickelsen called attention to the fact that numerous examples that have been brought out do not allow for the increase of torque but merely serve as slipping clutches that reduce the speed without varying the torque materially. In connection with transmission efficiencies the speaker explained that under very favorable conditions the power-loss through the gear transmission is small but that the loss may be extremely great under adverse conditions. Efficiencies of from 90 to 95 per cent may be expected from the average transmission in summer whereas the efficiency may drop to the 80 to 85-per cent range in winter driving when low temperatures are encountered. The losses were shown by curves to be largely due to oil-pumping of the countershaft gears which revolve continuously.

EASE OF CONTROL

Proper chamfer on the mating gears and good sliding-fit of the gears on the shaft make for easy operation and control. Difficulties arising from the use of clutch-brakes to overcome the clutch inertia have been partly eliminated by reducing the radius at which the friction surfaces act, thus making it unnecessary to provide the brake.

A number of devices have been designed with especial reference to easy control; they make possible the shifting of gears by the use of electromagnetic, hydraulic, pneumatic or



THE COMBINATION AUTOMATIC CLUTCH AND TRANSMISSION INCLUDES AN AUTOMATIC CLUTCH, AN OIL-PUMP AND A FOUR-STAGE OIL-MOTOR FOR TORQUE VARIATION

special mechanical arrangements. In this connection the Campbell transmission was described. Other systems of gear-shifting include those using (a) means for gear selection through a device on the steering-column with the shifting accomplished by movement of the clutch pedal and (b) hydraulically operated clutches that bring into action the proper gears which are constantly in mesh.

ELIMINATION OF GEARS

Numerous attempts have been made to eliminate gears from the transmission and to use in their stead electric, hydraulic or friction units. The electric type combines a generator, a control system and a driving motor. The use of a magnetic clutch for driving directly through high gear with a high efficiency resulting was said to be a desirable feature. The combination of mechanical and electrical features of certain types appears to be unnecessarily complicated. In using an electric transmission it is possible to dispense with the flywheel, clutch, gears, the present small generator, the starting motor and one set of brakes. In view of this elimination the electric transmission offers attractive possibilities. In fact this type has been used successfully, especially in England.

In the hydraulic systems a hydraulic motor, a pump, a control system and suitable piping are included. The plunger type of pump apparently meets the requirements most satisfactorily. Hydraulic systems seem at best rather complicated and they present possibilities for numerous difficulties on operation.

The wearing of flat spots on the fiber discs of friction transmissions was said to be the chief cause for practically eliminating this type from use in automobiles, although a number of light cars and motorcycles that use the system are still in the field. The best efficiency attainable with the friction transmission is about 95 per cent which is reduced to as low as 50 per cent under unfavorable conditions. The outstanding advantages claimed for friction transmissions are simplicity and cheapness.

In the attempt to make the transmission and torque variation automatic several interesting mechanisms have been developed. These include such transmissions as the de Lavaud and the Constantinesco. By the use of slides Professor Nickelsen described these types briefly.

TRANSMISSIONLESS CARS

Attention was called to the possibility of eliminating the transmission from automobiles. The recent trip from coast to coast with the transmission locked in high gear was cited as a demonstration of this possibility, although it was stated as an impractical solution with the present units in the hands of average drivers.

In conclusion Professor Nickelsen discussed the possibilities of the reversing gear. An interesting arrangement was described and illustrated with slides. The following



SHOOTING CLAY BIRDS OVER THE ATLANTIC WITH RAIL-BIRDS
LOOKING ON

words were used to summarize the situation with which the transmission is so vitally connected:

If it is feasible to produce lighter-weight cars, obtain higher speed, build more flexible engines and possibly reduce the maximum car-speed somewhat, it seems only reasonable to expect a transmissionless car. From a study of recent progress in the automobile industry and the direction in which new development is pointing it appears only logical to expect this end in the not distant future. Certainly a transmissionless car is that which is most desired from the standpoint of cost, better efficiency, simplicity of design and ease of operation.

AN AUTOMATIC CLUTCH AND TRANSMISSION

After summarizing briefly the development of various types of transmission, W. E. John, of the Automatic Clutch & Transmission Co., described a system combining an automatic clutch and a transmission that is intended to eliminate some of the difficulties and disadvantages characteristic of other arrangements. The speaker's description explained the manner in which the automatic connection and disconnection of the direct-drive relationship of the engine and the propeller-shaft are obtained and also the manner of obtaining an increase of engine torque applied to the propeller-shaft in forward and reverse directions.

The system comprises two clutches, a direct-drive clutch operated in the flywheel with its driven member attached to the propeller-shaft, and a low-speed and reverse clutch that is normally engaged when the direct-drive clutch is disengaged and vice-versa. The direct-drive clutch is controlled by centrifugal weights that engage or disengage it at the proper speeds of rotation. The low-speed clutch drives a rotary oil-pump that furnishes a means of applying power to a four-stage rotary oil-motor. The clutches, the pump and the motors are concentric as is the double-acting roller-clutch behind the rear oil-motor. A cylindrical control-valve regulates the discharge and direction of flow of the oil to the motors. Torque variation from direct-drive to the point of greatest torque is accomplished automatically by the centrifugal weights and by step-by-step connection of the four stages of the oil-motor through the control valve.

OTHER PAPERS

Two other very interesting papers presented at the Transmission Session are printed elsewhere in this issue. They relate to a positive mechanical continuous-torque variable-speed transmission and constant-mesh transmissions described respectively by Edward B. Sturges and W. A. McCarrell.

After a very limited amount of discussion concerning dimensions and points of operation, Chairman J. A. Anglada brought the session to a close with appreciative remarks relative to the presentation of the very interesting and instructive papers. Models of several of the devices and a car equipped with one of them were examined after the session.

A DUST-BREATHING ENGINE CANNOT LIVE

Usefulness of Air-Cleaners Discussed and Requirements Analyzed

Anyone interested in engines from the viewpoint of long life and uninterrupted performance with consequent reduction in repair-cost would have profited by the Air-Cleaner session of the Summer Meeting which convened in the ball-room of the Monmouth Hotel, Friday, June 27, at 9:30 a. m.

It was evident that all the speakers were convinced of the usefulness of air-cleaners and the service that would result from their installation, but the opinion was expressed more than once that designers of air-cleaners and manufacturers of automotive vehicles would have to give thought and study to this matter both separately and cooperatively before air-

cleaners would become generally used. The papers and the discussion brought out valuable data relative to the requirements that a good air-cleaner must fulfill, reasons why air-cleaners are not more generally used, advantages and disadvantages of certain types, and methods used in testing air-cleaners to ascertain their desirability or undesirability.

AIR-FILTERS

L. L. Dollinger, chief engineer of the Staynew Filter Co., presented a paper dealing with air-cleaners of the filter type. The paper is printed in this issue of *THE JOURNAL* on p. 66, but as an introduction to the discussion that followed its presentation a resume of its main points is included here.

More dust is in the air than is generally supposed to be the case, much of it highly abrasive. When this dust is taken into the engine, excessive wear is imposed on the cylinders, the pistons, the rings and the grooves with a consequent reduction of the effectiveness of compression and an increase of crankcase-oil dilution. Moreover, much of the trouble commonly attributed to carbon deposits is believed to be due not so much to the carbon itself as to the mixture of dust and carbon; the carbon would in many instances be burned away were it not mixed with the incombustible material taken into the engine with the dust.

Mr. Dollinger spoke about the cost involved in repairing a worn engine and stated his belief that the use of air-filters would result in prolonged engine-life and a decrease in the frequency and the amount of repairs necessary. He mentioned as generally prevalent the belief that keeping out the coarser particles of dust is the chief function of an air-cleaner, the finer particles being rather negligible; but he expressed his opinion that the finer particles are the more destructive, because they work more readily into the space between the piston and the cylinder-wall and between the piston and the piston-rings and make their way more easily into the crankcase oil.

In enumerating the features most desirable in an air-filter, Mr. Dollinger mentioned small size, light weight and few moving parts. For a passenger car an air-filter should in addition be neat in appearance and noiseless in operation.

In the discussion, R. C. Darnell spoke of the high cleaning efficiency of air-filters but gave as an offsetting disadvantage their tendency to clog and in this connection emphasized the necessity for placing the filter in a suitable position. Certain tests were described in which the engine was equipped with a filter placed near the breather, as a consequence of which position the filter became clogged with oil spray. The fact was stressed that a well-designed air-filter, properly placed, cuts down appreciably the amount of dust taken into the engine with a consequent lengthening of the latter's period of usefulness. Prof. A. H. Hoffman expressed his belief that as a general thing oil did not harm the filter, although there might be certain filter materials on which the oil would have a bad effect.

Replying to a question asked by R. E. Wilson, Mr. Dollinger stated his opinion that the major part of the damage from dust takes place on its first passage into the engine before reaching the crankcase, although he has done no special experimental work that supports this view. V. C. Young agreed with Mr. Dollinger that the greater part of the damage caused by dust takes place when the incoming fuel deposits this foreign matter on the cylinder walls, rather than by re-circulation. A. L. Clayden expressed interest in the statement relative to the size of the particles doing the most damage, and in reply to Mr. Clayden's question Mr. Dollinger stated that no extensive study of that kind had been made but that such experimental data as were available indicated that the greater damage is attributable to the finer particles.

Professor Hoffman referred to the breather as a cause of wear to which little consideration has hitherto been given and mentioned the fact that in most tractors and in at least one light automobile the breather is placed where it gets a large quantity of dust. Mr. Darnell described an improved design of breather, known as the flapper-valve type, which is believed to keep out dirt to a greater extent than does the ordinary breather.



L. L. DOLLINGER



P. S. TICE

WHY WE DO NOT USE AIR-CLEANERS

A brief paper was presented by P. S. Tice, director of the carburetor division of the Stewart-Warner Speedometer Corporation, in which he discussed reasons why air-cleaners are not generally used. After introductory remarks relative to the usefulness of air-cleaners, Mr. Tice stated that in view of the service that this type of device is admittedly capable of rendering to cars, some reason or reasons must exist to explain why cars are not generally so equipped. He gave as these reasons the following: ignorance, avoidance of an issue that has not become personally acute, cost of air-cleaner equipment, inefficiency of cleaners already used, and difficulties in operation and car performance that have resulted from attempts to use air-cleaners.

The first three items received little more than mere mention. Relative to the inefficiency of various cleaners, the author stated humorously that no sufficiently good cleaner is as yet available that is small enough to install in a car in which no space has been left for it; an air-cleaner, to be applied satisfactorily, must be contemplated in the design of the car. The operative aspects that are considered of the greatest importance are (a) the effect of the cleaner upon engine output, (b) the effect of the cleaner upon the metering of fuel in the carburetor and (c) the care required by the cleaner. In this connection, Mr. Tice believes that a good cleaner, when clean, will, if it is suitably proportioned to the engine, cause a relatively small loss of possible output and will affect the metering of fuel no more than can be taken care of in the specification or adjustment of the carburetor.

Concerning the size of dust particles that cause the most damage, Mr. Tice stated that the more injurious effects come from what may be called the intermediate sizes; very large particles do not enter readily and very fine ones are of such small dimensions that they may be considered as becoming imbedded in the oil-film and only occasionally touching a metal surface. In general, the larger the particles that can enter, the greater will be the damage, once entry has been made. In this connection reference was made to cases of excessive rates of wear in cylinders fitted with pistons of more than ordinary clearance.

The essential requirements of a good air-cleaner are that it possess a high degree of efficiency, that it impose a negligibly small pressure-loss and that it continue to function with the minimum of attention.

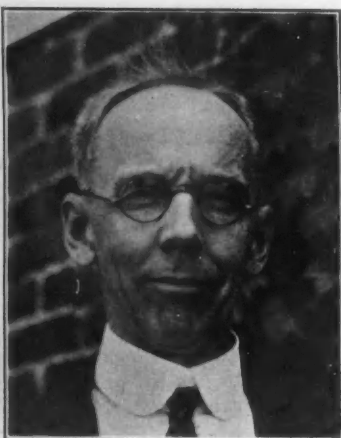
Commenting on Mr. Tice's paper, H. M. Crane stated his opinion that a well-fitted piston is far less likely to wear out the cylinder than a loosely-fitted one and relative to the size of particles causing the greater wear, stated his belief that a dust particle that is finer than an oil-film cannot cause wear.

THE TESTING OF AIR-CLEANERS

A. R. Squyer introduced his paper entitled *The Testing of Air-Cleaners* by stating three requirements of a good air-cleaner: (a) maximum of efficiency, (b) minimum of atten-



C. P. GRIMES



A. H. HOFFMAN

tion and (c) minimum of power loss. The paper, which is printed on p. 33 of this issue of *THE JOURNAL*, describes some tests made in 1921 to find the cleaners best capable of fulfilling these requirements. The statement is made that air-cleaner designers must give thought to the amount of care needed to keep the cleaner in good working order, with a view to bringing this amount down to the minimum, and another matter for study is the method of attaching the air-cleaner to the carburetor.

An interesting and noteworthy feature of Mr. Squyer's paper is the fact that it includes unsatisfactory as well as satisfactory results, and the value of this procedure from the point of view of his audience was brought out repeatedly in the discussion.

It was thought that it might be possible to combine the air-cleaners and the supercharger in some way. In this connection it was pointed out that the poorest kind of power to use in cleaning the air is the airstream entering the engine. If very high efficiencies are to be attained, it might be desirable to use the power of the engine in some mechanical way to separate the dust from the air, rather than use the feeble power of the incoming air to accomplish this result.

F. C. Mock pointed out that if it is desirable to avoid loss of power, while maintaining a high cleaning-efficiency, a much larger and more expensive cleaner would be needed, and he suggested that some sort of compromise will be necessary. A. J. Scaife suggested that hitherto air-cleaners have been asked to fulfil too many requirements and he questioned whether the right requirements were being emphasized. The point had been made repeatedly that a high efficiency was always sought, although such efficiency meant restricting the airflow and decreasing the power. Mr. Scaife felt that a cleaning device that would not restrict the airflow and that would require very little attention, should be counted as a distinct gain if it lengthened the life and increased the per-

formance of the engine, even though it were of much lower efficiency than that now thought most desirable.

ROAD AND LABORATORY TESTS OF CLEANERS

For the last 2 years, the University of California Test Farm engineers have been investigating air-cleaners. These investigations have been most thorough and the results have been accepted as authoritative and unprejudiced throughout the automotive industry. It was decided therefore to bring one of the university engineers East to the Summer Meeting to tell something about this work, particularly with reference to the testing of air-cleaners for passenger cars and trucks. A. H. Hoffman, who has been directly connected with this testing work, read an unusually interesting paper in the Air-Cleaner Session. This paper will be printed in full in an early issue of *THE JOURNAL*.

Mr. Hoffman said that every air-cleaner built can be made to test out 100 per cent efficient if one only chooses the dust to be fed into it. He does not think that any satisfactory substitute for standard air-floated dust exists. If only a single mechanical principle were involved in air-cleaner design, it might be possible to find a satisfactory substitute. If the air-cleaner manufacturer wishes to test his product to determine the best design, the use of a substitute may easily lead to erroneous conclusions. Mr. Hoffman has found that fuller's earth is not a satisfactory standard dust for testing. The use of a dust substitute is not only undesirable, but unnecessary. Mr. Hoffman assured his audience that, if a dust comparable in physical characteristics with the University of California No. 1 Standard is made up by mixing air-floated portions of several representative soils obtained from a given region, the results will be more reliable than can be obtained with any substitute.

ROAD-TESTS OF AIR-CLEANERS NOT ALWAYS RELIABLE

Road-tests of air-cleaners are not always reliable. A laboratory test under controlled conditions is much more desirable. A road-test must determine two things: (a) how much dust the carburetor would take in if no cleaner were used and (b) how much dust the tested cleaner either catches or fails to catch. Results of a road-test of a Rickenbacker car equipped with an air-cleaner were given by Mr. Hoffman. These are presented in Table 1. The cleaner under test was placed in its normal position on the car. An absolute or 100-per cent efficient cleaner was inserted between the standard cleaner and the carburetor. All joints were made air-tight. The hood remained closed throughout the test. Dusty conditions were produced by running another car 50 ft. ahead of the one under test. The driver of the forward car maintained a constant speed of 25 m.p.h. and the following driver endeavored to maintain the 50-ft. interval and to keep the radiator of his car in the densest part of the dust cloud. In comparative tests the leading car should always be of the same make and model, and the drag, if one is used, should be of the same kind and similarly placed. In the tests covered in the table, a chain loop made of a steel chain 25 ft. long and having links 1 1/2 x 2 1/2 in. was used as a drag.

TABLE 1—ROAD-TEST OF AIR-CLEANERS

Run	Cleaner	Miles	Elapsed Time, Min.	Average Speed, M.P.H.	Vacuum at 25 M.P.H., In. of Water	Dust in Absolute Cleaner, Grams	Dust Per Mile, Grams	Efficiency, Per Cent	Conditions—		
									Dust	Temperature, Deg. Fahr.	Humidity
1	Absolute Only	16.40	42.5	23.1	.....	31.35	1.91	...	Med. Hvy.	87.0	48.0
2	No. 23 of 1922	32.60	86.0	22.8	3 to 5	34.12	1.55	32.3	Heavy	95.0	37.0
3	I. & M. Perfection	32.60	81.0	24.1	3 to 5	40.35	2.41	49.6	Heavy	95.0	36.0
4	Cyclone Automatic	13.00	33.0	26.0	3 to 5	7.52	2.41	76.0	Heavy	87.0	43.0
5	Absolute Only	9.70	26.5	22.0	.....	23.42	2.41	...	Heavy	83.0	48.5
6	Absolute Only	9.75	25.5	22.9	.....	22.27	2.28	...	Heavy	95.5	28.0
7	I. & M. Perfection	9.80	24.0	24.5	3 to 4	3.40	2.28	84.8	Heavy	93.0	39.0
8	I. & M. Perfection	26.00	64.5	24.2	3 to 4	2.61	0.60	83.2	Medium	82.0	42.0
9	Absolute Only	13.00	26.7	29.2	7.77	0.60	...	Medium	77.0	53.0

MEETINGS OF THE SOCIETY

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TABLE 2—SUMMARY OF 1924 SERIES OF TESTS

Make or Trade Name	Type	Dust-Separating Efficiency, Per Cent			Abrasive Removed in Service Run, Per Cent	Vacuum at 20.4 Hp. and 1200 R.P.M.	
		Average of All Tests	Service Run	Low Water		Cleaner Clear	100 Grams of No. 1 Standard Dust
Twister	Dry	...	44.7	...	45.1	7/8	7/8
Case	Wet	96.7	97.4	94.6	97.7	2	2
Protectomotor C-4 ^a	Dry	99.8	99.7	...	99.7	3/4	1 3/8
Protectomotor C-4 ^a	Dry	99.8	99.5	...	...	3/4	2 1/8
Protectomotor C-4 ^a	Dry	...	99.8	...	...	9/16	1 (50 grams)
Bennett	Oil	98.4	99.2	...	98.7	1 3/4	53 3/8
Bennett	Oil	...	98.9	...	99.2	5 9/16	29 3/4 (50 grams)
Simplex	Oil	98.7	97.5	...	97.2	15/16	11
Simplex	Oil	99.2	99.6	...	99.2	1 7/16	31
Hose	Dry	99.7	99.9	...	...	2 1/4	3 3/8
Gordon	Dry	99.9	99.9	...	99.8	3 1/8	5 7/8
Gordon	Dry	98.2	97.0	...	96.9	5 7/16	9 3/4
Winslow 10 in. ¹	Oil	98.4	98.6	...	98.5	2 5/16	2 5/16
Winslow 8 in. ¹	Oil	99.9	99.8	...	99.3	3 3/16	3 3/16
Turbo Automatic ²	Dry	55.9	47.2	...	49.9	3	3
Cyclone Automatic ²	Dry	62.7	74.9	...	76.8	3	3
Thompson ³	Dry	24.0	9.6	...	7.7	5 1/2	5 1/2
Thompson ³	Dry	80.4	...	...	...	6	6
Donaldson, WHL	Dry	88.0	...	...	...	3 3/8	51
Midwest	Oil	62.8	73.2	...	73.1	1 1/2	1 1/2
Dailey 7 1/2 in.	Oil	99.9	99.8	...	...	4 7/8	6 1/8
Pomona 142	Oil	95.9	94.8	...	95.2	2	2
Palmer, A. E.	Dry	...	50.0	...	50.3	3 7/8	3 7/8

^a The first two of these are almost exact duplicates, one furnished by the manufacturer, the other sent in by a buyer. The third is the same as the first except that it has no staples through single thickness of the felt.

¹ Each of these has a small air-inlet at the base to operate an air-lift type oil-pump.

² Each of these has a dust outlet about 1 in. in diameter. That on the first is conchiform; that on the second is the frustum of a cone. The tests run on these cleaners were special and unofficial. While No. 1 standard dust was used, the regular dust feed was not used.

³ These have a centrifugal air-pump with a runner measuring 6.2 in. in diameter and 1 in. wide. The first has a 2.5-in. pulley for belt drive; the second is arranged for direct motor drive up to 6000 r.p.m.

COMPARATIVE TESTS OF STOCK AIR-CLEANERS

Thirty-two cleaners, 20 different kinds, from 17 manufacturers or inventors are entered in the 1924 test series of the University of California. Fifteen are designed principally for automobile use, 11 others are usable for either automobile or tractor, and only 6 are primarily for tractor use. These last mentioned, together with some late arrivals, are not yet all tested. The lists will remain open until late summer or early fall and the test results will appear in later issues of THE JOURNAL. Data resulting from the tests completed to date are presented in Table 2.

DO AIR-CLEANERS REDUCE WEAR?

What effect the air-cleaner will have on engine wear is being studied by a number of large commercial organizations using fleets of trucks or automobiles. Only a very limited amount of information is available. One engineer reports from Los Angeles as follows: Two Buick Six touring cars ran almost exactly 27,000 miles each in the same service. One was without an air-cleaner, the other was equipped with one of high efficiency. The average cylinder wear in the first was 0.008 in. and in the second 0.001 in. The engine of the car without a cleaner required several new rings, valves and other parts, the second required none. Another engineer reports from New York City: A Model AB Mack truck equipped with a good air-cleaner showed 0.0025-in. cylinder wear after 8368 miles of operation. This wear occurred at the extreme top of the ring travel, tapering to no measurable wear 1 in. down. The rod bearings had not been touched in 33,427 miles and showed a clearance of 0.002 to 0.003 in. The wear apparently was all in the babbitt as the pins were still within the original permissible limits.

Among the interesting features of Professor Hoffman's presentation was a reel of motion pictures that showed very graphically the conditions encountered in road-tests of air-cleaners. At the conclusion of the reading of the paper Chairman Hunt stated that the time available was not sufficient to allow for the consideration and informal discussion that the paper merited. He suggested that numerous members would undoubtedly desire to contribute written material to be published later. In the same connection the chairman

stated that additional test data and other material resulting from Professor Hoffman's work would be given first publicity at an early date in the columns of THE JOURNAL. A number of the members commented very favorably upon the wealth of useful information of a very definite nature presented by the speaker. It was hoped that his work would be continued for the benefit of all concerned.

During the interval between Professor Hoffman's paper and that of C. P. Grimes, Thomas Midgley, Jr., was given an opportunity to speak briefly about the most efficient and satisfactory use of the anti-knock fuel produced by his company. It was pointed out that certain difficulties may result from the deposition of lead compounds upon the exhaust-valves after continued use of the fuel. The speaker explained that the sticking of valves occasioned by this cause could be remedied or avoided by the use of a small quantity of kerosene at infrequent intervals and by making sure that the valves are at all times sufficiently free.

CENTRIFUGAL TYPE OF CLEANER

C. P. Grimes presented a brief description of a centrifugal type of air-cleaner or dirt ejector and explained its operation. The device is constructed so that the air enters through guide-vane openings at the top and is then cleaned by centrifugal action brought about through a rotating member supported by a ball mounted upon a felt support that serves to relieve vertical shocks and to lubricate the bearing. The dust particles and the air containing them are thrown outward and are removed automatically and continuously from the bottom of the cleaner. The cleaned air passes to the carburetor with very slight opposition to the flow.

In the discussion of Mr. Grimes' paper it was reported that the air-turned rotor of the cleaner described would operate with the car running on high gear at as low a speed as 3 m.p.h. on a level pavement. This was said to be very important in certain types of service where a high cleaner-efficiency is required at low engine-speeds. A member stated that the appliance would withstand abuse and would operate even when oil, water or other materials were poured into it. These were said to be ejected satisfactorily.

Mr. Grimes stated that he had left out some of the details as to test data owing to the lack of time to present them.



AN ADJOURNED DISCUSSION

A. W. S. Herrington with the Megaphone in His Hand and A. M. Wolf Figuring Out the Broad Jump Winners

RESEARCH COMMITTEE MEETS

Riding-Qualities and Fuel Research Among Major Projects Discussed

Elsewhere in this issue of THE JOURNAL will be found a report covering progress in the cooperative fuel research in which the Society is associated with the American Petroleum Institute, the Bureau of Standards and the National Automobile Chamber of Commerce. The recent work on this project was discussed at length by the members of the Research Committee at their meeting of June 26. It was reported that the continuance of this very important work is assured, and the members felt that the results thus far attained have been of inestimable benefit to the industries involved and to the general public as well.

FUEL SPECIFICATIONS

In an attempt to obtain the views of the automotive industry on various phases of fuel specifications the leading manufacturers of automobiles and engines have been asked by the Research Department to comment on certain specific items as they affect the powerplant. Among the most important of these is sulphur, and comparatively little has been said until recently about the injurious effects of this material as it is fed to the engine as a part of the fuel. The effects of corrosion and etching of parts subjected to the compounds that include sulphur should be eliminated so far as possible by keeping the sulphur-content of the fuel as low as practicable. In this connection it is believed that the experience of engine builders should furnish an accurate index of the suitable limits of the sulphur-content, and a result of this belief is the endeavor to collect the available information on the subject and the plan to formulate the material in such a way as to make it ready for use in stating in detail the type of fuel most suitable for automobile engines. The undertaking outlined above was initiated by the fuels group of the Research Committee, and it is hoped that considerable benefit to automobile users may ultimately be derived from it.

RIDING-QUALITIES RESEARCH

A paper on riding-qualities research prepared by a member of the Society's Research Department appears on p. 75 of this issue. It includes a statement of the problem, an analysis of conditions encountered in driving, a summary of methods and instruments used in past and present investigations and an outline of proposed work. In the section of the paper last mentioned, attention is directed to the importance of establishing the relation between definite motions and forces and their effect upon the passenger. It is believed that too little thought has been given to this aspect of the problem.

Among the first steps that have been taken in connection with the riding-qualities project of the Research Committee

are (a) establishing contact with those who have been engaged in the investigation of various phases of the problem; (b) studying the literature and preparing a comprehensive bibliography. Many consultations have been held with investigators throughout the industry. Among the agencies with which contact is sought are those representing the physiological and psychological phases. It is believed that close cooperation should be established with these interests. As for the bibliography above mentioned, about 700 references, of which many have been abstracted, have been collected thus far. This material will be made available to interested members who may request it.

It is planned to promote the general discussion of riding-qualities research and to formulate a program of investigation that should bring forth material of value in aiding in the solution of the problem.

OTHER PROJECTS

Among the other subjects in connection with which progress was reported the following should be mentioned: safety code work on automobile brakes and brake testing, crank-case-oil dilution, gears and balloon tires.

A summary of routine activities of the Research Department since the March 12 meeting of the committee comprised correspondence to the extent of approximately 650 letters in connection with the information service, the preparation for THE JOURNAL of the Notes and Reviews columns and other material including Automotive Research and other items.

Those who attended the June 26 meeting are mentioned in the following list:

H. W. Alden	F. C. Mock
O. C. Berry	E. C. Newcomb
O. M. Burkhardt	T. S. Sligh, Jr.
H. M. Crane	S. W. Sparrow
H. C. Dickinson	P. S. Tice
T. J. Little, Jr.	E. P. Warner
Thomas Midgley, Jr.	J. A. C. Warner
R. E. Wilson	

HIGHWAYS COMMITTEE MEETS

Members Discuss Impact-Tests and Plan Work for the Future

Among the projects in which the Society's Highways Committee is interested, the work in connection with the impact tests with trucks now in progress at the City of Washington is perhaps the most important. It will be recalled that the Society and the Rubber Association were invited to cooperate with the Bureau of Public Roads in this work.

Chairman Bachman took occasion at the Spring Lake meeting of the Highways Committee on June 25 to report briefly the status of the project at the time of his recent visit to the Bureau of Public Roads Experimental Farms at Arlington, Va. It seems that the important problems of instrumentation that have been somewhat perplexing are settled to the satisfaction of the Bureau officials who are now expediting the actual impact-tests with trucks of different types vari-



BALANCING EXTRAORDINARY

Feminine Members Transporting Eggs at Spring Lake



THE STRUGGLE OF THE BOYS OVER 40

ously equipped. It is believed that the time devoted to obtaining suitable and reliable instruments has been well spent, for without them the results of the extensive road-tests would be of doubtful value.

As previously reported, the program of experimental work includes tests with trucks carrying an accelerometer from the records of which the impact forces imposed upon the road and the truck may be determined. Various types of tires for the trucks and different degrees of loading are included among the variables. The actual test runs are taking place along a stretch of concrete roadway, made up of slabs of different thicknesses and mounted upon different subgrades. Strain-gage and other measurements are taken on the slabs when the trucks pass over them and strike obstacles of definite dimensions. In order that practical conditions of test may be used, a certain amount of preliminary work is being done on the regular highways. It is possible by the use of the accelerometer in these runs to determine the suitable vertical accelerations to be reproduced upon the test road from which the measurements of strain are taken. From the impact-tests it is hoped that considerable material of value as regards both vehicle and road design may come.

During the meeting herein reported considerable general discussion was had on the relation between the automobile and the type and condition of the highway. Particular attention was called to the importance of surface smoothness. A very slight degree of unevenness may account for destructive effects upon the highway and unsatisfactory riding conditions of the vehicle. It was pointed out that most satisfactory conditions from the automobile passenger's standpoint result from running over a surface that is more or less yielding and capable of damping the vehicle vibrations. The question of suitable width of road surface was also considered.

Final plans were made for a meeting in the City of Washington on June 30 when the Society's committee will meet with the Bureau of Public Roads officials and members of the Rubber Association Committee. At that time it will be possible to review the work thus far accomplished and to inspect the apparatus and truck equipment.

STANDARDS COMMITTEE MEETING

Many Important Division Reports Approved for Adoption by the Society

The meeting of the Standards Committee at Spring Lake, N. J., on June 25 was convened by Vice-Chairman C. C. Carlton, the registered attendance of Committee and Society members and guests being 62, with a quorum of 18. Of the 30 reports submitted by 8 Divisions, 28 were approved in either their original or an amended form. The report of the Aeronautic Division was withdrawn by letter ballot of the Division members subsequent to their publication in the June issue of *THE JOURNAL*. The report of the Agricultural Power Equipment Division on Tractor Leather Driving Belts, which was withheld following the Annual Meeting last January and revised somewhat, was approved in part, while the Parts and Fittings Division's report on Compression-Type Tube Fittings was referred to the Council for disposition as a matter of policy when patents that may apply in the case

are involved. An additional report on Motor Vehicle Acetylene Head-Lamps, printed in full on p. 27 in this issue of *THE JOURNAL* and recommended by the Lighting Division, was approved for adoption as S. A. E. Recommended Practice. The modified report of the Springs Division including the cancellation of the present S. A. E. Recommended Practice for Passenger Car Springs, p. H8 of the S. A. E. *HANDBOOK* was approved.

The action taken by the Standards Committee was approved by the Council immediately thereafter and by the reconvened Business Session on Friday morning.

The account of the action taken on the Divisions' reports, the pertinent discussion thereon and the attendance, will be found beginning on p. 25 of this issue of *THE JOURNAL*. The reports will be submitted to letter ballot of the Society Members in accordance with regular procedure and prepared for publication in the S. A. E. *HANDBOOK*.

MANY INTERESTING EXHIBITS

Members Have Opportunity to Inspect Units and Instruments of New Design

Many interesting exhibits were shown at the Summer Meeting. Some of these were related to the subjects discussed at the technical sessions, others were shown informally. The Motor Transport Corps of the United States Army exhibited and demonstrated a four-wheel drive military



PEERING UNDER THE BONNET OF A STEAM-COOLED CAR

transport truck that exemplified the latest advances made in the design of systems driving all wheels. This unit is known as the 1½-2 ton TTL model. The Bureau of Standards exhibited some of the apparatus that has been used in recent crankcase-oil dilution investigations. The Bureau also showed a car with four-wheel brakes which was equipped with a complete brake-testing equipment. In addition to having a recording decelerometer mounted in the tonneau, this car was fitted with a number of thermocouples to



THE MODEL TTL 1½ TO 2-TON FOUR-WHEEL DRIVE TRUCK EXHIBITED BY THE MOTOR TRANSPORT CORPS

measure brake-band and brake-drum temperatures during actual operation of the brakes under ordinary service conditions. Means were provided to indicate the brake-pedal pressure on a large pressure-gage mounted in the front compartment.

Cut-out models of the Weiss continuous-torque transmission and the Cotta constant-mesh transmission were exhibited in the Transmission Session. Cars equipped with the McCarrrell constant-mesh transmission and the Weiss transmission were demonstrated to the members. A cut-out model of the Skinner device for combating oil dilution was shown in one of the Dilution Sessions.

The Mack seismograph and the seismograph developed under the supervision of Professor Lockwood were displayed in the Riding-Quality Session. A Norton accelerometer was also available for the members to examine.

Among the informal exhibits one found a car equipped with airbrakes, another with the brakes controlled by a vacuum cylinder, a car using the Rushmore steam cooling system and one equipped with a special form of hot-spot manifold. The Firestone Tire & Rubber Co. had five balloon-tire-equipped cars at the meeting for members who wished to study recent engineering alterations made to offset wheel shimmy and hard steering. There may have been other informal exhibits, for there always seemed to be groups gathered here and there peeping inquisitively under raised bonnets or peering curiously underneath chassis for hidden mysteries.

THE DAILY SAE A PICTORIAL REVIEW

Unstinted credit is due Oscar F. Ostby who, as editor-in-chief of *The 1924 Daily SAE*, had charge of seeing that each morning the members found at the breakfast table a full account of the accidents, sports, technical sessions and social affairs of the preceding day. To print a live four-page daily paper is no little task. It was even harder this year as photographs, taken in the morning, appeared in the paper the following day, speed that a city daily does not exceed. The pictures, taken by Nate Lazarnick and others, were developed in the hotel and sent to Trenton by messenger. The cuts were delivered to the printer in Lakewood before 3 o'clock



THE BRAIN POWER OF *The Daily SAE*
From Left to Right, Alexander Johnston, Oscar Ostby and Frank Parrill

in the morning and the papers were in the dining rooms by 8 o'clock.

The cost of *The Daily SAE* was borne entirely by the Prest-O-Lite Co. Credit is due Alexander Johnston and F. L. Parrill, who, as associate editors, carried the larger part of the load and burned the midnight oil literally as well as figuratively. Six thousand copies of the Friday issue were printed and sent to all the members of the Society in order that those who could not attend this year would be able to read about a small part of the doings of their more fortunate brothers.

HEADQUARTERS TO BILL SECTION DUES

Plan Agreed Upon at Representative Meeting of Section Officers at Spring Lake

With representatives from 11 of the Society's 12 Sections on hand and a 100-per cent attendance of the Sections Committee, it must be recorded that the Spring Lake Sections



LEADING LIGHTS OF THE SECTIONS

Luncheon was a decided success. Many of the problems that have arisen in the administration of the Sections during the last year were thoroughly discussed. Several important policies were recommended to the Council.

The most important of these had to do with the collection of Section dues through the headquarters office of the Society instead of by the treasurers of the Sections. Hereafter the bill for dues in the parent Society will include an item for Section dues. In the case of members who have heretofore been affiliated with a Section, the payment of this additional item will be presented as an obligation. When a Society member has never taken out membership in a Section, or where no Section is located in his immediate vicinity, the Section dues item will be included as an optional charge payable only if the member wishes to become a member of one of the Sections. It is expected that this system will not only relieve the Section treasurers of a large part of their clerical duties, but that it will appeal to Section members as a convenient method of remitting their Section dues. In cases where members have never seen fit to participate in the meetings and activities of the Society's local outposts, an effort will be made to convince them of the value of this local service.

SECTIONS TO OPERATE ON BUDGET PLAN

It has been customary during the last 2 or 3 years to make appropriations from the parent Society to the Sections on the basis of a formula that took account of the number of Society members in each district and the number of these who paid dues to the Section.

While this arrangement has many good points, particularly in avoiding any feeling that partiality is practised in any specific case, it has not been found entirely satisfactory. This for the reason that some of the Sections have been able to accumulate substantial surpluses, while others have had

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difficulty completing their activities with the funds in hand. Following a recommendation reached in a recent meeting of the Sections Committee, a budget scheme of making appropriations was submitted to the Section representatives for their consideration. With slight modifications, this was agreed upon as the basis for future Section appropriations from the national body. This arrangement will require that the Governing Committees of all Sections submit estimates of expenses and income for the administrative year to the Sections Committee before Sept. 1. These budgets will be approved or modified by the Sections Committee and submitted by it to the Council. When each of the budgets has the approval of the Council, the Treasurer of the Society will be authorized to pay each Section such funds as are needed to carry out the plans contemplated in the approved budget, taking into account the anticipated income that the Section will receive from local dues. It is expected that this plan will be effective for the coming Section season and all Sections will be required to prepare and submit their budgets before the first of next September.

CHANGES IN SECTION MEMBERSHIP POLICY

It was the sense of the Sections Luncheon gathering that members of the Society should not be required to make formal application for membership in the Sections but should become members without further formality upon payment of dues to a Section. A recommendation was made to the Council that affiliate member representatives and enrolled students be permitted to join the Sections, but only after making formal application for membership and being accepted by the Governing Committee.

Following action on these matters of policy and administration, the members lunched together and listened to informal reports by representatives from each of the Sections. These reflected a condition of effective activity in all Section centers except one. Peculiar business and industrial conditions have made it difficult to maintain interest in Section meetings in this one center, but the officers are showing a commendable spirit in carrying-on despite economic handicaps. J. H. Hunt, chairman of the Sections Committee, presided at the meeting and luncheon. He closed the program with a valuable talk on meeting paper subjects for the coming year. Many of the Section representatives submitted additional suggestions of topics and authors. A complete list of these program suggestions will be forwarded to all Section officers through the medium of the *Sections Bulletin*.

SECTION STUNTS ENLIVEN MEETING

Aerial Bombs, Toy Airplanes, Guessing Contests and Tramping Troubadours

Following the custom inaugurated many years ago on the boat-trip meetings, some of the Sections inserted features into the Summer Meeting to impress the crowd fully with their presence. For example, A. K. Brumbaugh appeared to be an incessant boomer, or should we say bomber, for the Pennsylvania Section. Equipped with an assortment of aerial bombs, he was continually crashing huge holes in the



FOUR DETROITERS FINISH THE DAY'S WORK

From Left to Right They Are H. D. Church, M. P. Rumney, Neil McMillan, Jr., and Olney Jones

sea breezes and dropping decorative material from the heavens. One bomb sprinkled small red keystones all over the place.

Cleveland Section tested the attendants' powers of observation and their knowledge of automotive products by conducting a pictorial guessing contest throughout the meeting period. Cards were distributed at each meal carrying untitled pictures illustrating automotive products made in Cleveland. Credit goes to Mrs. Fred Cornell of Detroit for her familiarity with trinkets and gadgets springing from the factories in Cuyahoga County. A beautiful traveling bag was her reward.

Detroit Section's stunt was all up in the air. Small paper airplanes imprinted with praises of this dynamic district were distributed among the dinner assemblage one evening. Soon the air was filled with miniature monoplanes and all dignity disappeared while the crowd enjoyed the sport with childlike enthusiasm.

Though it cannot be recorded as a Section stunt because of its heterogeneous membership, Phil Overman's Orpheus Troupe pleased the multitude immensely. Friend Phil's strumming banjo enlivened the carryings-on of his harmonious followers as they wound their serpentine procession through the dining rooms crooning an edifying chantey that mentioned something about "there ain't no flies on us."

LADIES' SPORTS ATTRACT MANY ENTRIES

Mrs. C. Foster Captures First Prize in the Golf Tournament, Mrs. G. Ralls Second

Many card games and sports events were provided at Spring Lake for the large representation of ladies present at the Summer Meeting. The social program in charge of Mason P. Rumney and the ladies' sports events left no time for idle moments or twiddling of thumbs. Mah Jongg and



BUCKWALTER WINS THE HEAVYWEIGHT CHAMPIONSHIP



THE LADIES TRY FLINGING THE SPHERE OF OUR NATIONAL PASTIME



WATCHING THE LADIES THROW THE BASEBALL

bridge tournaments were held every day and attracted anywhere from 25 to 40 ladies. The first prize for bridge on Tuesday afternoon was won by Mrs. W. R. Flannery, Mrs. C. Foster winning the second. Miss C. Cramer was the successful bidder on Wednesday morning, Mrs. A. E. Clifford being second. Mrs. C. T. Klug turned in the highest tally card on Thursday, Mrs. F. A. Cornell being second. On Friday morning Mrs. M. H. Schmid was awarded first prize and Mrs. F. A. Cornell the second.

Mah Jongg tournaments were run at the same time as the bridge. Mrs. B. Brede received first prize Tuesday morning, Mrs. N. Bell second. Wednesday morning Mrs. H. A. Tarantous scored the highest, Mrs. N. Bell second. Mrs. J. Gray was given first prize Friday morning and Mrs. V. W. Klierath second.

Everyone turned out for the big dance on Thursday evening at the Essex and Sussex Hotel. The ladies were so attractive in their gayly colored gowns that the stronger sex had to be on the alert to procure a partner for every dance. As usual the evening held so much excitement that the music ended all too soon.

F. W. DAVIS TAKES GOLF HONORS

Golf continues to hold the center of the Summer Meeting sporting stage. Apparently the idea of trying to draw straight lines with an irresponsible rubber pellet appeals to the average technical mind. At any rate, it must be commented that some engineers have passed the low state of inaccuracy so prevalent on golf courses of the present day. The Spring Lake tournament was shortened this year by altering the method from match to medal play. Over 80 knickered knights trudged through the 18 qualifying holes on Tuesday or Wednesday in an effort to land among the low 64 who would be fortunate enough to participate in the final round on Thursday. Dusky-hued clouds flashed over the course on Wednesday afternoon and deposited an unwarranted amount of moisture, driving caddies and golfers to shelter. One of the latter was R. E. Wilson, who chose



R. E. WILSON'S UMBRELLA IN A STATE OF COLLAPSE

a supposedly substantial garage as his umbrella. The high wind picked this garage as a mark for a little golf of its own and promptly flattened it out on Wilson's head. It was really miraculous that he escaped with no greater injury than a slight scalp wound. After a little patching up, Wilson finished the round. Low qualifying score was turned in by M. H. Cox, who totaled a mere 85 strokes.

Those turning in the low 64 scores for the qualifying round were divided into four classes; Championship, Class A, Class B and Class C. These 64 men played the final round on Thursday afternoon with the following results:

Championship—	F. W. Davis	86
	M. H. Cox	88
	C. E. Salisbury	89
Class A—	Webb Jay	94
	Neil McMillan, Jr.	95
	E. Wooler	96
	T. L. Lee	96
Class B—	J. W. White	99
	F. H. Martin	101
	G. S. Case	102
Class C—	W. G. Wetherby	97
	E. O. Jones	100
	J. B. Eccleston	101

Thus Francis Davis carries the honors and the medal of S.A.E. Golf Champion for the year 1924.



F. W. DAVIS, THE SMILING 1924 GOLF CHAMPION

CLEVELANDERS WIN AT BASEBALL

Figgie's Sandlotters Take Both Metropolitan and Detroit Nines Into Camp

Cleveland Section's baseball troupe won its second leg on the S.A.E. Baseball Cup at the Spring Lake meeting. Only three teams were entered in the series and it was Cleveland's all the way. The opening battle brought the forces of the Metropolitan and Cleveland Sections into conflict. To use an old saying, this was no sooner said than done. Harry Figgie pitched air-tight ball and the representatives of Manhattan Isle succeeded in doing little but knocking brilliantly placed fouls or practising their sundry swings on the seashore breezes. Few balls passed the infield and the scorer did not recall any one of the Knickerbockers having reached first base. While the Metropolitan crew were thus inoffensively conducting themselves, the boys from

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Erie's shore were emulating Babe Ruth and the other satellites. Net result: Cleveland, 13, or thereabouts; Metropolitan, 0.

This preliminary exhibition enabled Figgie's followers to uncrook their arms and sharpen their ocular senses for the set-to with the Dynamic Detroiters. This was a battle royal between the long and short of the Society's pitching talent. Figgie and his 60 odd inches faced Jardine and his 6 ft. 4 in. of dominance. But David trimmed Goliath. Neil McMillan, Jr., contributed the solitary Detroit thrill when he streaked a home run over the heads of the Cleveland outfield. Fred Cornell, Detroit's man behind the bat, allowed a foul tip to make merry with his spectacles but caught better after ridding himself of these useless appendages. The Cleveland outfield was strengthened appreciably by the presence of Casey Jones, who discarded his ineffective mitt for an efficient waste-basket. A. K. Brumbaugh, seated with his feet dangling from a fourth-story window sill, kept up the morale of both clubs by shouting down uncomplimentary words of encouragement from his station as bird's-eye-view observer. Since the official scorekeeper kept his records on the back of a visiting card, it is not possible to go into minor details such as hits, errors, wild pitches and the mere technicalities. Let it suffice to say that no triple plays or brilliant one-hand catches were executed. Oh yes, the final score of this argument was Cleveland, 9; Detroit, 2.

DOWNPOUR DAMPENS TENNIS FINALS

Doubles Played in Sea of Mud and Singles Final Has to Be Postponed

Oil will not mix with water and everyone seems to take it for granted. But the doubles tennis finalists at Spring Lake tested out a new theory that tennis will mix with water; the net result was MUD. One of the illustrations on this page gives some conception of the conditions underfoot after the final scrimmage was over. Norman Shidle and Herbert Chase, eminent automotive scribes, outskidded and outspattered Coker Clarkson and Stanley Bates. When the contestants finished, they rivaled little Tommy after a hectic morning manufacturing mud-pies. J. P. Nikonow, seated under a good Samaritan's umbrella, umpired the contest. The match was concluded in straight sets, 6-1, 6-4, 6-2. Both of these teams had an easy time reaching the final round.

Fortunately, the singles finalists, Clarkson and Shidle, both live in New York City. This made it unnecessary to stage a second mud-slinging contest to decide the singles title. The match will be played off in the near future and the results will be published in the August issue of THE JOURNAL. There were over 20 entries in the singles tournament and many fast matches were contested. The following summary gives the results up to the final round:

First Round.—B. J. Lemon defeated J. J. McElroy, 6-1, 6-2; C. F. Clarkson defeated Rollin Abell, 6-1, 6-0; R. E. Carpenter defeated C. O. Rhys, 6-2, 7-5; L. C. Hill defeated W. M. Rognon, 6-2, 6-1; A. K. Brumbaugh defeated R. E. Plimpton, 6-2, 6-0.

Second Round.—Herbert Chase defeated C. T. Klug, 6-2, 6-0; B. J. Lemon defeated H. R. Cobleigh, 6-0, 6-1; J. P. Nikonow defeated B. B. Bachman, 6-2, 6-1; C. F. Clarkson defeated R. E. Carpenter, 6-1, 6-0; C. F. Scott defeated L. C. Hill, 6-0, 6-1; L. H. Brown defeated R. G. Cornforth, 6-2, 6-2; S. E. Bates defeated A. K. Brumbaugh, 6-1, 6-1.

Third Round.—Herbert Chase defeated B. J. Lemon, 6-3, 6-4; C. F. Clarkson defeated J. P. Nikonow, 6-2, 2-6, 6-3; N. G. Shidle defeated C. F. Scott, 6-0, 6-3; S. E. Bates defeated L. H. Brown, 6-1, 6-0.

Semi-Final Round.—C. F. Clarkson defeated Herbert Chase, 1-6, 6-3, 8-6; N. G. Shidle defeated S. E. Bates, 6-2, 6-4.

Final Round.—Postponed due to rain. Will be played off in New York between N. G. Shidle and C. F. Clarkson.

METROPOLITAN SECTION WINS CUP

Winning of Medal for All-Round Athlete Hinges on Postponed Tennis Match

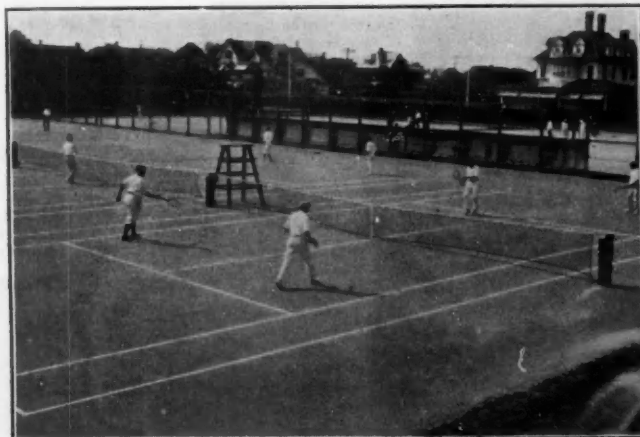
As a result of Metropolitan Section athletes winning 179 points as against 93½ won by Detroit Section members and 71 by Cleveland Section members, the Metropolitan Section won the Inter-Section Trophy for the third consecutive year. The trophy consequently becomes the property of the Metropolitan Section. The conditions under which the Sections competed for the cup during the last three years were similar to those used at intercollegiate track and field meets. The cup was competed for first at White Sulphur Springs in 1922.

Owing to the fact that the final match between Norman G. Shidle and Coker F. Clarkson for the tennis singles was postponed on account of the rain that occurred on the last day of the meeting, it is impossible to decide the winner of the medal for the All-Round Champion. Adding the number of points the loser of the tennis singles would win to the number of points won by N. G. Shidle and C. F. Clarkson, Gordon Brown and Mr. Shidle would be tied with a total of 25 points and Mr. Clarkson and F. W. Davis with a total of 20 points. As either Mr. Shidle or Mr. Clarkson will gain an additional 5 points by winning the tennis championship, the chances are even that N. G. Shidle will win the medal or that Messrs. Brown, Shidle and Clarkson will tie for first place.

ATLANTIC SEABOARD WELL PROTECTED

Blunderbuss Experts Pepper Ocean Waves and Make Many New Records

Each day of the meeting found many members on the beach in front of the Essex and Sussex Hotel bringing down the clay pigeons thrown out over the surf. On Tuesday, R. S. Ellis made the high net score with a 49 out of a possible fifty; F. D. Heath made the highest gross score; in a special doubles shoot W. H. Miller and R. M. Owen won



TENNIS FAIR AND FOUL
The Picture at the Right Shows the Mud Party in the Doubles Finals



A SQUAD OF TRAPSHOOTERS AT REST

Its Members Reading from Left to Right Are F. D. Heath, R. S. Ellis, Bill Miller, Orrel A. Parker and R. M. Owen

the highest net and gross scores respectively. On Wednesday, L. C. Porter made the highest gross score and A. G. Metz won the Quail Shoot. On Thursday, R. S. Ellis made the highest net score, breaking 46 out of the 50 clay pigeons sent seaward, and G. A. Lyon and L. L. Williams won the Protection Race Championship. On Friday, R. S. Ellis again made the highest net score, breaking 47 out of a possible 50, and W. J. Mueller made the highest gross score.

Over 30 members took part in the different events, many of whom never had had a gun in their hands before. Handicaps were based on the scores of the previous day. D. J. Cooke, advertised on the S.A.E. Flyer as a crack shot, brought down 23 out of a possible 200 during the four days' shooting.

LIBBY WINS HORSESHOEING CONTEST

The second year of the horseshoe-throwing contest showed that A. D. T. Libby had spent his time since last year in earnest practice, for, instead of coming in third as last year, he showed his heels to all the blacksmiths and won the championship. In the finals, he beat W. J. Buettner 22 to 12 and 22 to 7, making three ringers in the last game. In the doubles, A. D. T. Libby and C. F. Gilchrist beat W. L. McGrath and W. J. Buettner 19 to 21, 21 to 10 and 21 to 19. There was a large number of entries. Engineering was involved as measurements with a steel tape as close as 1/32 in. were necessary to preserve order among the numerous contestants.

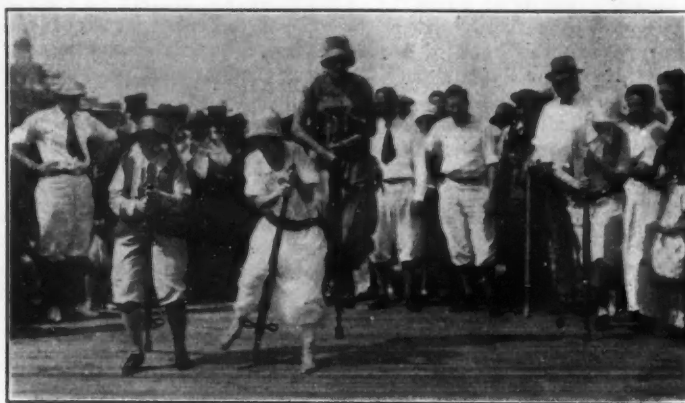


THE HORSESHOE FLINGERS HAVE A BIT OF AN ARGUMENT

POGO STICK FARCE A HUGE SUCCESS

Earth Tremors Reported by Spring Lake During Progress of the Fat Men's Race

If the apparent amusement of the spectators was any indication, the pogo stick races on the Boardwalk were the hit of the entire Summer Meeting program. Owing to either surreptitious practice, or an act of providence, Olney Jones was able to keep his balance until he could fall across the finish line. L. C. Porter was the second to cross, but as he was hopping backwards at the time and as the finish line had been moved 30 ft. nearer the starting line in the hope that someone would be able to qualify for the second prize, possibly he did not intend to do so. After a total of 98 failures to finish and as many new starts, the judges declared that the remaining four contestants were Mexican Jumping Beans and called the race off.

THE HIT OF THE FIELD DAY
Trying To Conquer the Balky Pogo Sticks

The field events were held on the strip of lawn running between the Boardwalk and the Parkway paralleling the beach, directly in front of the Monmouth Hotel. The weather was delightful, there being a cool sea breeze that was inductive to new records. The complete list of events and the winners are given in the following summary:

50-Yd. Dash (Men Under 30)—First, Olney Jones; second, C. S. Bruce; third, J. O. Elsinger
50-Yd. Dash (Men 30 to 40)—First, Nell McMillan; second, J. C. Talcott; third, D. R. Swinton
50-Yd. Dash (Men Over 40)—First, T. V. Buckwalter; second, E. R. Gurney; third, Rollin Abell
50-Yd. Dash (Boys Under 15)—First, Dan Foster; second, Bob Germane; third, Joseph VanBlerck, Jr.
50-Yd. Dash (Women)—First, Miss M. J. Thacher; second, Miss E. Tygert; third, Mrs. C. F. Scott
Fat Men's Race—First, T. V. Buckwalter; second, A. I. Brumbaugh; third, R. E. Wilson
Shot Put—First, Rollin Abell; second, T. V. Buckwalter; third, L. C. Porter
Three-Legged Race—First, L. C. Porter and D. R. Swinton; second, C. S. Bruce and J. O. Elsinger; third, H. C. Dickinson and C. E. Heywood
Potato Race (Men)—First, Nell McMillan; second, T. S. Sligh, Jr.; third, R. E. Carpenter
Potato Race (Women)—First, Miss E. Tygert; second, Mrs. T. B. Fordham; third, Mrs. S. P. Thacher
Standing Broad Jump (Men Over 40)—First, F. G. Whittington; second, T. V. Buckwalter; third, O. C. Berry
Standing Broad Jump (Men Under 40)—First, B. W. Brodt; second, F. F. Kishline; third, Gordon Brown
High Jump—First, J. C. Talcott; second, W. I. Rogers; third, B. W. Brodt
Throwing the Baseball (Women)—First, Mrs. W. J. McKenzie; second, Miss E. Tygert; third, Miss J. McKenzie
Egg Race (Women)—First, Miss E. Tygert; second, Mrs. A. G. Metz; third, Mrs. D. E. Gamble
Inter-Section Relay Race—First, Detroit; second, Washington; third, Metropolitan
50-Yd. Dash (Novice Race for Men)—First, J. H. Shoemaker; second, T. S. Sligh, Jr.; third, E. S. Fraser
Pogo Stick Race (Men)—First, Olney Jones; second, L. C. Porter
Pogo Stick Race (Women)—First, Miss M. J. Thacher; second, Mrs. A. G. Metz.

The Porter Sisters were sincerely missed in the baseball-throwing contest, but Mrs. W. J. McKenzie showed that third place in the Annals of the Society was undisputably hers

MEETINGS OF THE SOCIETY

21

when she cleared the crowd, which had closed in on the contestants as a result of the first few throws, on her first attempt.

The fat men's race was impressive. Arthur Herrington thought for a moment that the Tank Corps had arrived from Washington. F. E. Moskovics, who was not used to traveling in such fast company, strained his leg and was laid up for the rest of the meeting.

SWIMMING EVENTS DAMPENED BY RAIN

Brumbaugh Entertains Audience with Characterization of Baby Girl Lost on Beach

Although a steady rain came down during the entire afternoon, A. K. Brumbaugh was able to draw out a large gallery for the swimming events by a whirlwind speaking tour of the hotels aided by buses and 4-in. bombs. In the 66-yd. race, Gordon Brown was seized with cramps and was only able to come in second, Sanford Brown winning first place. Gordon Brown was shamefully accused of either having examined the prizes and preferring the one for second place, or of having had a bad case of brotherly love. The winners of the various events are given below.

33-Yd. Swim (Ladies)—First, Mrs. McKenzie; second, Miss Clarkson

66-Yd. Swim (Men)—First, Sanford Brown; second, Gordon Brown

Plunge for Distance—First, A. K. Brumbaugh; second, R. Abell; third, Sanford Brown

Novice Swimming Race—First, T. H. Wickenden; second, C. S. Bruce; third, Sanford Brown

Egg Race (Men)—First, Neil MacCoull; second, Gordon Brown; third, R. Abell

Egg Race (Ladies)—First, Mrs. McKenzie; second, Miss Clarkson

Fancy Diving—First, C. S. Bruce; second, Miss Clarkson; third, Sanford Brown

Plate Diving Contest—First, A. K. Brumbaugh; second, Gordon Brown; third, Neil MacCoull

33-Yd. Swim—First, Gordon Brown; second, Neil MacCoull; third, R. Abell

Water Golf Contest—First, Gordon Brown; second, Neil MacCoull; third, A. K. Brumbaugh



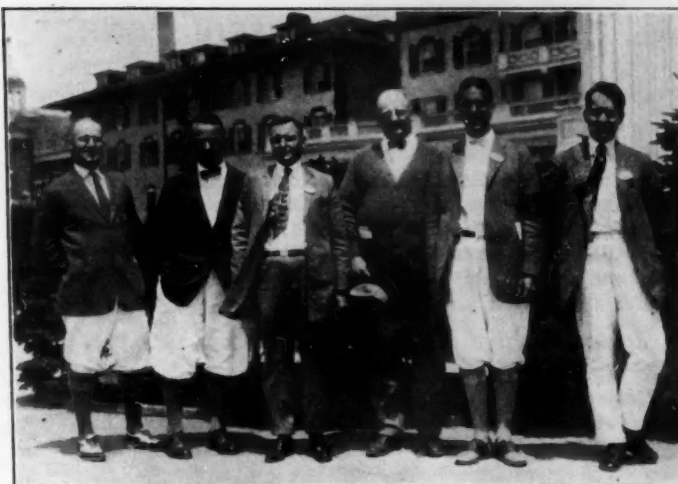
A CHILD ASTRAY

Philadelphia's Lone Wanderer at the Swimming Carnival

During a lull in the rain, a thick-set baby girl weighing about 250 lb. appeared in red and white gingham and bonnet to match, carrying a tin pail and spoon. After transferring a few pails of water from the children's pool to the large pool, she realized she was being watched and, missing her mother, set up a cry of increasing magnitude for "Mama." The agitation of the child was so apparent and pathetic that she was cared for by several of the S.A.E. ladies.

SUMMER MEETING WORKERS THANKED

S.A.E. Summer Meetings could not be the success they are if it were not for the whole-hearted cooperation of all committeemen, no matter how small their tasks may be. The comprehensive medley of sports, entertainment and technical meetings demands the closest of supervision by those in



THE SPORT COMMITTEE IN PART

From Left to Right They Are Fred Cornell (Golf), A. K. Brumbaugh (Swimming), A. D. T. Libby (Horseshoes), A. C. Bergmann (General Chairman), Gordon Brown (Swimming) and E. P. Warner (Tennis)

charge of the arrangements. All this takes place behind the scenes and it seems appropriate to record the names of the self-sacrificing workers in closing this account of the successful gathering at Spring Lake. Of the Meetings Committee, T. J. Little, Jr., chairman, A. C. Bergmann, M. P. Rumney and R. E. Wilson were active in handling the general administration. The numerous divisions of the sports program were under the general supervision of A. C. Bergmann, who directed the Sports Committee consisting of the following:

SPORTS COMMITTEE

A. C. Bergmann, General Chairman

GOLF

Fred Cornell, Chairman.
Sanford Brown
W. E. Kemp

BASEBALL

T. V. Buckwalter, Chairman

SWIMMING

A. K. Brumbaugh, Chairman
Gordon Brown

TRACK AND FIELD

A. C. Bergmann, Chairman
A. W. S. Herrington
M. P. Rumney
A. M. Wolf

TENNIS

E. P. Warner, Chairman
J. P. Nikonow
Carl F. Scott

TRAPSHOOTING

W. H. Miller, Chairman

HORSESHOES

A. D. T. Libby, Chairman

Previous mention has been made of the high caliber of the many technical papers. No attempt will be made to commend each author individually, but it should be recorded that the Council and Meetings Committee are most appreciative of their efforts in preparing and presenting manuscripts that are a distinctly valuable addition to the literature of the Society. It is also important to mention those who spoke so frankly and openly in the discussions of the papers and thus added much material to the contributions of the authors. The several chairmen of the sessions are thanked for their part in directing the discussions so that the greatest value could be got from them.

The International Motor Co. is thanked for repeating its

excellent bus service of 1923. Three buses were operated on a regular schedule between the hotels, golf courses, station and other centers of activity. A luxurious de luxe type bus carried the ladies on a sightseeing tour Thursday morning to the Naval Air Station at Lakehurst, where the airship Shenandoah was inspected in her hangar. M. C. Horine was in charge of this trip and the bus service in and about Spring Lake.

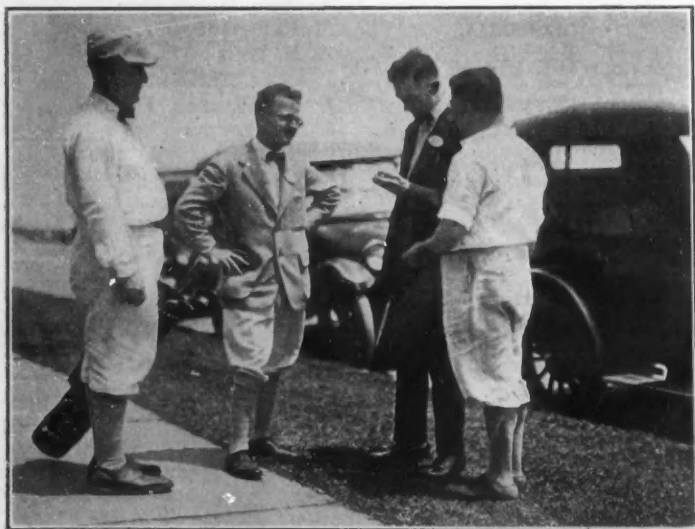
PAST YEAR A PROSPEROUS ONE

Society Has Added to Surplus Despite Broadening of Its Activities

Treasurer Whittelsey's report showed the Society to be in a particularly healthy financial condition at this time. At the close of business on May 31 last, its excess of income over expenditures was \$12,420.74, which compares with \$1,908.66 at the same time last year. The Society's reserve has been appreciably increased as will be noted in the following statement:

COMPARATIVE BALANCE SHEET, MAY, 1923-1924		
ASSETS	1924	1923
Cash	\$10,329.69	\$24,275.99
Accounts Receivable	29,193.72	35,031.47
Securities—Cost Value	133,205.32	96,550.63
Accrued Interest on Securities	1,977.64	1,548.83
Inventories	8,224.52	7,965.75
Furniture and Fixtures	8,078.80	7,792.54
Items Paid in Advance		
Charges Deferred	10,650.82	10,528.54
TOTAL ASSETS	\$201,660.51	\$183,693.75
LIABILITIES AND RESERVES	1924	1923
Accounts Payable	\$9,362.14	\$6,411.50
Dues and Miscellaneous Items		
Receivable in Advance to Be Credited Monthly	28,268.26	27,826.27
Reserves Set Aside for Anticipated Expense	11,097.75	24,848.06
Prize Fund Balance		817.66
General Reserve	140,511.62	121,881.60
Unexpended Income	12,420.74	1,908.66
TOTAL LIABILITIES AND RESERVES	\$201,660.51	\$183,693.75

The decrease in Cash On Hand is explained by the recent



GOLFERS TEMPTING A TECHNICIAN IN MUFTI
From Left to Right They Are Webb Jay, E. Wooler, H. L. Walker and W. C. Munson

investment of a part of these funds in Government securities. Despite the general increase in the business of the Society the Accounts Receivable item has decreased. The large increase in the value of securities reflects the investment of unexpended income that has accrued during the last 12 months. Over \$100,000 of this surplus is invested in securities of the United States Government.

Mr. Whittelsey reported that the Harvard Economic Service stated recently that we are not entering a period of depression. A general forecast of business activities naturally includes activities in the automotive industry; therefore the Society must be prepared to handle bigger problems than ever before. To maintain its present sound financial position the Society needs an increasing number of new active members. These must be substantial men who will be capable of assuming and willing to assume an active part in the personal service required to keep the Society in the lead of the greatest industries of the world today.

ACTIVE CAMPAIGN FOR NEW MEMBERS BEING MADE

That an effort is being made to follow this policy was shown by the report of Chairman Strickland of the Membership Committee. It stated that during the last 3 or 4 years no extensive campaign has been conducted to increase the membership of the Society. From 500 to 750 applications are received each year without solicitation. This increment is usually offset by the loss of an equal number of members through non-payment of dues, resignation and other causes.

In view of the fact that the Society has recently broadened its activities to include direct benefits to production men, service men and operators of fleets of motor trucks and motorbuses, President Crane and the present Membership Committee have felt that something should be done to increase the membership. What is most wanted is the acquisition of new members capable of adding to the value of the professional discussions at Society meetings. A plan to interest engineers, production managers, service managers, fleet operators and general executives was outlined and put into effect about April 1, with the result that, through the cooperation of the members, 70 applications were received during the month of April, as compared with 56 for the previous April; and 115 applications were received during the month of May, as compared with 59 for the previous May. The Membership Committee earnestly desires that the entire membership cooperate with it to the extent of sending in the names of men in the industry who would be benefited by Society membership. When it is realized that the Society is a cooperative organization, it can be readily seen that it is to the advantage of every member constantly to inject new blood into the organization.

The comparative table given below indicates the number of members of various grades, affiliate representatives and enrolled students on the rolls of the Society on June 1, 1923 and June 1, 1924.

	June 1, 1923	June 1, 1924
Members	2,768	2,737
Service Members	89	87
Foreign Members	78	97
Associates	1,527	1,521
Juniors	639	527
Affiliates	110	107
Total Membership	5,211	5,076
Affiliate Representatives	109	203
Enrolled Students	244	253
Total Enrollment	5,564	5,532

The above figures for 1924 are net, after deducting the following: deceased, 13; resigned in good standing, 137; dropped as delinquents, 389; total, 539.

The Council approved at its June meeting 130 new applications for membership.

WHERE WILL THE 1925 SUMMER MEETING BE HELD?

Chairman Little of the Meetings Committee reported that in recognition of the great value of National Meetings to the membership and the industry, the officers of the Society have increased the number of these meetings and the scope of their programs with each succeeding year. After giving the schedule of meetings for the coming year he discussed two important problems of meetings work; the location of the Summer Meeting and the solicitation of papers. There has been some comment on the desirability of holding the Summer Meeting nearer the geographical center of the industry and of our membership. As stated many times, this is largely a matter of finding a suitable location where adequate hotel and sports facilities will be found to accommodate an assembly which sometimes numbers close to 900 persons. Almost any location on the shores of the Great Lakes would be desirable, but no resort of suitable character and size has been found. Expressions from the members on a location for the 1925 Summer Meeting are desired.

Mr. Little's report endeavored to correct two mistaken impressions encountered generally among the members. First, there is a general belief that papers are given before a National meeting only upon personal invitation from the Committee. On the contrary, all members are urged to submit papers to the Committee at any time for presentation at National meetings. Such cooperation will be most highly appreciated. The second misunderstanding relates to tardy requests for representation on National meeting programs. It is not generally understood that the programs for most of these meetings are completed at least 2 months in advance of the meeting dates. To avoid disappointment, members are asked to study the schedule of future meetings and make known to the Committee their desire to be included on any of the programs at the earliest possible date.

SECTION PROBLEMS RECEIVING CAREFUL STUDY

The past year has been one replete with Section problems. The Council and the Sections Committee have been devoting considerable time and thought to the solution of these as they have arisen. As a result of these deliberations, several important steps have been taken and these were reported by Chairman J. H. Hunt for the Sections Committee. In summary form these are:

- (1) Sections have been authorized to charge meeting admission fees to non-Section members
- (2) It is proposed that the Constitution be amended so that the Sections Committee will consist of members elected by the Sections, one by each Section, and three members appointed by the President, the President to appoint the chairman of the committee
- (3) The Council has voted that Section Officers be notified that Section funds should not be used for free dinners or other entertainment with-

out previous approval of the Council

- (4) Bonding of Section Treasurers has been recommended
- (5) The executive staff has been requested to collect the data and draft a budget form for making appropriations to the Sections, this system to supplant the present method of making appropriations based on a formula
- (6) Full Section privileges have been accorded the Milwaukee Section
- (7) The name of the former Mid-West Section has been changed to Chicago Section

Mr. Hunt reported that the Pennsylvania Section has resumed activities in a very successful manner, and thanked the officers of this Section, and the other members, including the permanent staff, who contributed to this very satisfactory result.

S. A. E. EMPLOYMENT SERVICE

The Employment Service of the Society has placed 78 men in positions during the last 5½ months, an average of about one man every other day. Of this number, 8 were for temporary openings and the remaining 70 were for permanent positions with salaries ranging from \$40 per week to over \$5,000 per year. This service usually maintains an average of about 200 men on the employment list, more than half of whom are employed but are seeking better connections. About 8 out of 10 men receive answers to their notices of availability, some men receiving five or six answers, others only one or two. Companies inserting notices of positions available receive an average of about fifteen answers per opening. The Employment Service secures men for about three out of the four vacancies handled by it.

CLEVELANDERS HAVE PLAYFUL PICNIC

Close Very Active and Successful Year with Sport Outing

Cleveland Section's enthusiasm reached the bursting point on the afternoon of June 7. On that date ruddy-countenanced John Younger led his klansmen forth to the rolling meadows of the Cedarhurst Country Club, where considerable cavorting-about was indulged in. It was Cleveland Section picnic day! It was also Cleveland's first torrid day since August, 1923, but this did not wilt the spirit of the participants and their families. This annual picnic is a forerunner of the Summer Meeting of the Society and is the time for Cleveland athletes to train for the athletic events at Spring Lake.

The Cleveland Mercurys and Hermes showed their prowess in running events, jumping, shot putting, sack races, needle



F. S. Duesenberg



Ernest Wooler



J. G. Vincent



H. L. Walker

and thread races, golf driving contests and the usual burlesque of our national pastime. Meantime, some of the trap-shooting enthusiasts were blazing away at elusive clay pigeons. Following this unusual dissipation of physical energy, the hungry horde fled to the festive board and conducted themselves as hungry mortals should. Youngsters and wives who were along appeased appetites that had been whetted by an afternoon of convulsive laughter at the expense of the near-athletes.

Lack of space permits us to give only the winners of the numerous contests. Here they are for whatever glory they may get out of it:

50-Yd. Dash (Men over 30)—Tom Kemble
 50-Yd. Dash (Men under 30)—E. D. Kemble
 Running High Jump—Arndt
 Sack Race for Men—Arndt
 Tug of War—Saunders, Captain
 Dretke
 Frank
 Austin
 Riblet
 Buckwalter
 8-Lb. Shot Put—Blair

Golf Driving Contest—Williams
 Needle and Thread Race—Mrs. Dahlquist
 Broad Jump—Ernest Mydren
 50-Yd. Dash for Girls—Barbara England
 50-Yd. Dash for Boys—Donald Weaver

Jess Parker of the Jordan Motor Car Co. deserves great credit for his handling of the arrangements for facilities and food. E. W. Austin of the Timken Roller Bearing Co. worked up the athletic events and, not satisfied with that, picked out the prizes and toted them to the athletic field. John Younger's communication to *THE JOURNAL* says nothing about his part in the proceedings, but it is a safe wager that Williams and he labored industriously to make the picnic a success. At any rate, as the small-town paper would say, a good time was had by all.

SCHULTHEIS CLEVELAND TREASURER

In the list of Section officers published in the Chronicle and Comment Department of the June issue of *THE JOURNAL* an error was made in listing the Treasurer of the Cleveland Section. Henceforth E. M. Schultheis will act as guardian of the Cleveland Section's wealth.

JUNE COUNCIL MEETING

THE meeting of the Council held at Spring Lake on June 24 was attended by President Crane, Vice-Presidents Pope and Fordham, Councilors Scaife, Brumbaugh, Rumney and Hunt and Past-President Alden.

The following resolution on the demise of H. M. Swetland was passed:

The Council of the Society of Automotive Engineers feels a great loss in the passing of Mr. Swetland.

Just as the Society and the industry have benefited greatly from his sincere cooperation and advice, so will they miss him in their further progress.

In a large sense Mr. Swetland was the father of the Society, having been one of the first to initiate its organization over a score of years ago. His friendliness and helpfulness were continuous. There never was a time when he was not most willing to give the Society the benefit of his long experience and unusual business ability.

Mr. Swetland was a member of the first Council of the Society, that of 1905. He was also a member of the 1923 Council. As Chairman of the Finance Committee of the Society since 1910 he gave very effective advice to the Council, and the financial success of the Society should be attributed largely to him.

Mr. Swetland's greatest service was, however, not measured by his work in these capacities but was better exemplified by his strong and intelligent leadership in the solution of broad fundamental questions that the Society as well as the industry has had to meet.

The Council of the Society wishes to extend its heartfelt sympathy to the members of Mr. Swetland's family. He was a pioneer worker of an invaluable type.

The financial statement as of May 31, 1924, showed a net balance of assets over liabilities of \$152,932.36, this being \$29,142.10 more than the corresponding figure on the same day of 1923. The net revenue of the Society for the first 8 months of the current fiscal year amounted to \$153,099.14. The operating expense during the same period was \$140,678.40.

Some discussion was had of the plans for meetings of the Society to be held this year.

One hundred and thirty applications for individual membership were approved. The following transfers in grade of membership were made: From Junior to Senior Member, Harold W. Evans; Junior to Member, M. P. Ferguson, Ernest K. Hill, Karl W. Hooth, Arthur E. Jacobs, Frank H. LeJeune, William T. Livermore, Thomas W. Loring, Earl B. Maloon, Carl Francis Ogren, Samuel B. Roberts, Frank W. Schwinn, Maurice A. Singer, R. B. Templeman, Thomas H. White, Harold B. Winchell, Charles Froesch; Junior to Associate, Edward A. Blake, Carl R. Christman, Andrew Fletcher, Jr., Frank J. Lucas, James Leo Mayer, Willard F. Sanderson, Kenneth K. Stough, Louis B. Hall; Service Member to Member, Roger Birdsell; Association to Member, George Gunn, Jr., J. K. Honigman.

It was reported that on June 1, 1924, 5532 were on the rolls of the Society, including Affiliate Representatives and Enrolled Students, as compared with 5564 on June 1, 1923.

Paul E. Breneman was appointed to serve on the Passenger-Car Body Division.

W. B. Swift was appointed to serve as the S.A.E. representative on the Consulting Committee on Lumber (Soft Woods).

The next meeting of the Council will be held at New York City in September at about the time of the Automotive Transportation Meeting of the Society.



Standards Committee Meeting

THE regular semi-annual meeting of the Standards Committee was held at the Monmouth Hotel at Spring Lake, N. J., during the morning of June 26, with Vice-Chairman C. C. Carlton presiding. Twenty-six of the 28 original reports by 8 Divisions, which were printed on pp. 627 to 640 of the June, 1924, issue of *THE JOURNAL*, and two additional subsequent reports, were approved as presented or amended in the meeting. The action of the Standards Committee Meeting was approved by the Council and at the deferred business session on Friday morning, except in the case of the dimensional recommendations for compression-type tube-fittings.

In accordance with the Standards Committee regulations, a letter ballot of the Society members on final approval of the reports will be returnable and counted 21 days following publication in *THE JOURNAL* of the action taken on them at the Standards Committee Meeting. A ballot on the following reports is, therefore, returnable on July 24, 1924. The usual ballot-form will be sent to each Member of the Society and will provide for affirmative and negative votes and waivers. Each subject to be voted upon will be given in the ballots by title accompanied by the page reference of the report as published in the June issue of *THE JOURNAL*, which should be consulted by the members together with this issue in which is recorded the principal discussion on reports and the action taken on them.

Often letter-ballots on Standards Committee reports are returned unsigned by members. These, of course, cannot be counted. Also a considerable number of ballots are usually received after the date on which ballots are counted. Many of these ballots undoubtedly represent the opinion of members who are particularly qualified to vote on the subjects, and to avoid having these ballots thrown out it is urged that all members be particularly careful to sign their ballots and return them within the specified time.

The following includes only such changes as were made in the Division reports printed in the June issue of *THE JOURNAL* referred to above and the additional reports by the Lighting Division that were approved for submission to letter ballot by the members and the principal discussion of subjects at the Standards Committee Meeting. This report, together with the original reports published in the June issue, should be considered when filling in the letter ballots.

AGRICULTURAL POWER EQUIPMENT DIVISION REPORT

(1) TRACTOR LEATHER DRIVING-BELTS (June issue of *THE JOURNAL*, p. 631)

This report was approved in part.

THE DISCUSSION

PRESIDENT H. M. CRANE:—We have done some of this sort of standardization before, such as on insulated wire, but it seems to me we are getting too much into the methods of manufacture and questions of that kind when we specify permissible adulteration and restrictions of that sort in organic materials.

R. S. BURNETT:—The Division felt that although leather tractor driving-belts are not now used extensively it would be perfectly proper to have a specification of this kind in the *S.A.E. HANDBOOK*.

PRESIDENT CRANE:—It seems to me that we are going too far when we attempt to specify methods of manufacture. We may have done it before, but our greatest success has been in dimensional standards.

GEORGE S. CASE:—It seems to me that the American Society for Testing Materials is the body to which a specification of this kind could more properly be referred.

MR. BURNETT:—All this standardization work is carried on in cooperation with other bodies as much as we can. This particular specification has been worked out in cooperation with the Leather Belting Exchange.

MR. CASE:—Is this a specification that the Leather Belting Exchange has published?

MR. BURNETT:—They worked with us on this.

VICE-CHAIRMAN C. C. CARLTON:—If this is the specification adopted by the manufacturers of leather belting, then it ought to be all right.

PRESIDENT CRANE:—Our system of standardization is a little slow-acting in certain respects. If we put this in the *S.A.E. HANDBOOK* and 2 years from now we suddenly wake up to the fact that the people who originated it have made material changes in it, while our standard remains just as it was before, we shall be in an unfortunate position. I sympathize with Mr. Case's point of view that our biggest success is in confining our work to our own very definite field without any question from outside. It is hard to indicate the definite point to which we should go and at which somebody else takes hold. There is no definite point; our field and theirs overlap a little.

MR. CASE:—I do not know much about the merits of this specification, but it seems to me that it might be well to leave it out as I think we are getting onto debatable ground.

B. B. BACHMAN:—I feel that when we go into the question of specifying the materials that at least many of us in the organization are unfamiliar with, except in the most general way, we are getting out of our field. Whether we ought to adopt a specification of this sort as general information so that it will be available in the *S.A.E. HANDBOOK* for reference to those who look there for this information or whether we should not is a debatable subject.

Personally, I feel that when the specification is supported by a representative organization, we are not getting off our own reservation by putting in the hands of our members who wish to use that kind of information the best available information that we can get for them.

VICE-CHAIRMAN CARLTON:—Mr. Bachman, do you wish to make an amendment to approve the Division's report without these specifications, or definitely to label these specifications as coming from some definite organization?

MR. BACHMAN:—In the past I have taken the attitude that a meeting of this sort should not make much change in the reports of the Divisions, but I will make a motion for amendment, with the understanding that this is an agreement between the belting manufacturers and those of our Division who are most definitely interested in it, that this specification be published as general information and that, if it is a specification of another organization, that recognition of that organization be given for its work.

PRESIDENT CRANE:—The only justification for this report is that we specify capacities or ratings for leather belts of certain dimensions, and it might be fairly said that if belts are not made according to these specifications they might not come up to the rating. That is about the only excuse for having it in here, anyway.

F. G. WHITTINGTON:—It would seem in this connection that rather than strike out all this specification, we could retain everything except the leather-carrying and adulteration equipment. It seems to me that this is much the same as the work that was done on felts that was pretty thoroughly specified after about 2 years of work, although it is possible that this is going in a little deeper than we did for the felts.

VICE-CHAIRMAN CARLTON:—If the amendment is adopted, it will be published exactly as here, but as the recommendation of another society.

MR. CASE:—The automobile manufacturers are probably using \$1,000 worth of belting in production for every dollar's worth they will ever use for tractor drives, and it seems to me that when such specifications are worked out, they should be specifications for general purposes rather than for tractor belts.

VICE-CHAIRMAN CARLTON:—To bring this to a head, we have Mr. Bachman's amendment that was seconded. Let us vote upon the amendment.

[A rising vote was taken on the amendment and it was carried. The vote was then taken on the motion as amended and the motion was lost.]

VICE-CHAIRMAN CARLTON:—Mr. Case moves that the report be adopted eliminating all that part of the report from the word "specifications" to the end.

[The motion was seconded and carried]

PRESIDENT CRANE:—In voting upon this report, just what do we omit? Do we omit all the tables, including the length of laps, ratings and average thickness?

VICE-CHAIRMAN CARLTON:—It is my understanding that we are omitting everything from "specifications" down to the end of the page report on Tractor Belts.

PRESIDENT CRANE:—Does that include the Length of Laps table?

VICE-CHAIRMAN CARLTON:—Yes.

PRESIDENT CRANE:—That is satisfactory. I just wanted to be sure.

[The motion was carried]

(2) TRACTOR SPEEDS

(June issue of THE JOURNAL, p. 632)

The arrangement of this specification will be changed by grouping the speed of 10 m.p.h. under a separate subheading for industrial types of tractor as distinguished from agricultural types.

THE DISCUSSION

MR. BACHMAN:—I presume that the first three speeds in the report are agricultural and the 10 m.p.h. would be for industrial hauling.

MR. BURNETT:—Yes.

MR. BACHMAN:—Ten miles per hour is partly an optional speed, that is, according to this specification a tractor could be made without that speed. Is that correct?

MR. BURNETT:—Yes. Since this report was printed, we have decided to change the form in which it will be printed in the S.A.E. HANDBOOK, by separating the 10-mile speed from the others and giving it an appropriate heading.

MR. BACHMAN:—It seems to me that there is reason for having a definite specification of speeds for plowing work because it ties in with other apparatus,

but is there any necessity for having a definite, fixed speed of 10 m.p.h. for towing purposes? Would it not be better to mention that as a maximum?

MR. BURNETT:—The Division felt that a definite speed of 10 m.p.h. should be given for industrial hauling purposes.

MR. BACHMAN:—I do not see why it would be necessary to have a fixed speed for towing purposes.

PRESIDENT CRANE:—Has the man who makes practically all the machines used for industrial hauling been questioned on this? My experience is that his machines run very much faster than 10 m.p.h.

[The report was approved]

(3) TRACTOR SPECIFICATIONS (CANCELLATION)

(June issue of THE JOURNAL, p. 633)

(4) TRACTOR POWER TAKE-OFF SPEED

(June issue of THE JOURNAL, p. 633)

This specification was approved with the addition of tolerances of plus and minus 20 r.p.m.

THE DISCUSSION

MR. BURNETT:—The report on Tractor Power Take-Off Speed is a new subject and the Division feels that it is important to establish some standard for the speed at which the implement is driven. A canvass of the present practice of those using this type of power take-off indicates that 536 r.p.m. is about the proper speed.

The matter of tolerance for the speed was taken up recently and set at plus or minus 20 r.p.m. and should be included in the specification.

I move the adoption of the report as given here with the addition of the tolerance for the tractor power take-off speed.

[The motion was seconded and carried]

(5) TRACTOR CANVAS AND RUBBER DRIVING BELTS

(June issue of THE JOURNAL, p. 633)

BALL AND ROLLER BEARINGS DIVISION REPORT

(6) WIDE-TYPE ANNULAR BALL-BEARINGS

(June issue of THE JOURNAL, p. 633)

THE DISCUSSION

T. V. BUCKWALTER:—I move that the report of the Ball and Roller Bearings Division be accepted.

[The motion was seconded]

LEONARD OCHTMAN, JR.:—Are these proposed new widths used for any bearings at present?

F. G. HUGHES:—The new widths of bearings Nos. 200 to 205 are now in use and the old widths are being withdrawn from the trade. This meets with the approval of most of the makers of this type of bearing because the sale of the old-width bearings has been very limited in past years due to their small load-carrying capacity. The change in widths has already found acceptance in the industry.

[The vote was taken and the motion carried]

LIGHTING DIVISION REPORT

(7) PASSENGER CAR HEAD-LAMPS

(June issue of THE JOURNAL, p. 634)

(8) ELECTRIC INCANDESCENT LAMPS

(June issue of THE JOURNAL, p. 634)

(9) LAMP GLASSES

(June issue of THE JOURNAL, p. 635)

The phrase "with tolerances plus and minus 1/32 in." in the last line in the paragraph under Spot Lamp Diameters was deleted.

THE DISCUSSION

MR. CASE:—Is there any reason for the tolerance of plus or minus 1/32 in. in the spot-lamp glass opening?

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MR. BURNETT:—That is what was indicated to us by the lamp manufacturers.

C. A. MICHEL:—It has been customary, in specifying prism areas of lenses to have a plus or minus 1/32-in. tolerance on the diameter of the glass.

C. D. RYDER:—I think that the tolerances of plus or minus 1/32 in. does not belong in the last sentence of the paragraph in the report, and should be omitted.

VICE-CHAIRMAN CARLTON:—By common consent, we will eliminate "with tolerances of plus or minus 1/32 in." after the word "respectively" in the last line under "Spot-Lamp Glass Diameters" in the second column on p. 635. [The vote was taken and the motion carried]

(10) BASES, SOCKETS AND CONNECTORS

(June issue of THE JOURNAL, p. 635)

(11) MOTOR-VEHICLE ACETYLENE HEAD-LAMPS

At the meeting of the Lighting Division and several representatives of state motor vehicle administrators last March, the writing of specifications for motor-vehicle gas head-lamps was discussed. A subdivision was appointed, comprising A. J. Scaife, White Motor Co., chairman; M. E. Toepel, International Motor Co.; A. K. Brumbaugh, Autocar Co.; O. F. Ostby, Prest-O-Lite Co.; C. D. Ryder, Cincinnati Victor Co.; W. F. Little, Electrical Testing Laboratories; A. W. Devine, Commonwealth of Massachusetts; C. E. Banta, Adams & Westlake Co.; Russel Huffmann, Motor Vehicle Conference Committee; T. D. Pratt, Motor Truck Association of America. The industries that would naturally be more directly interested in this matter were circularized for comments on a specification based on the use of a 5/8-ft. burner, a nominal 6-in. mirror and a plain, clear glass front. The replies generally were very favorable and the subdivision proceeded to draft a specification. This was sent out for criticism, and as a result several modifications were made. At a meeting of the Lighting Division in Spring Lake, N. J., on June 25, the redraft that had been received was carefully considered, approved and recommended to the Standards Committee for adoption. The report is as follows:

Proposed S.A.E. Recommended Practice for Motor-Vehicle Acetylene Head-lamps

Acetylene head-lamps for motor vehicles shall comply with the following requirements.

1—CONSTRUCTION

The head-lamps shall be of substantial construction to withstand the shock and wear of ordinary usage. They shall be equipped with a 5/8-ft. burner, a 6-in. concave mirror and a clear, plain front glass.

Burners.—A 5/8-ft. burner is one that consumes 5/8 cu. ft. of gas per hour at normal gas pressure.

Mirrors.—A nominal 6-in. mirror is one that measures approximately 6 in. on the curved reflecting surface and from 5 1/4 to 5 3/4 in. in diameter straight across the reflecting surface, according to the curvature. They shall be of curved glass at least 3/16 in. plus 1/64 minus 0 in. thick; or of molded glass, ground and polished and at least 3/16 in. thick. They shall have a focal length of not less than 2 1/4 in. and not more than 2 1/2 in. from the reflecting surface.

Front Glasses.—Front glasses shall be of clear, plain, glass not less than 1/8 in. plus or minus 1/64 in. thick.

2—MARKS OF IDENTIFICATION

Each lamp must bear a distinctive designation prominently and permanently indicating the maker or name and type of the lamp. Each burner must be clearly marked to show the cubic feet of gas consumed per hour at normal gas pressure.

3—MOUNTING

Head-lamps shall be securely mounted so that the axes of the main light beams will be parallel to the axis of the vehicle, or tilted downward in the vertical plane not more than 3 deg.

4—OPERATION

Head-lamps shall be maintained in proper operating condition with the mirrors and front glasses clean and the burners secured so that the center of the gas flame shall be at the focus of the mirror. The gas pressure shall be regulated to produce the maximum flame having a flat top, which will produce a light of approximately 21 mean spherical cp.

THE DISCUSSION

C. A. MICHEL:—In addition to the printed report in THE JOURNAL, a report was submitted by a Sub-Division on Motor-Vehicle Gas Head-Lamps, which has been subsequently acted upon by the Lighting Division and approved for S.A.E. Recommended Practice. I move that the entire report be approved by the Standards Committee.

[The motion was seconded and carried]

NON-FERROUS METALS DIVISION REPORT

(12) WROUGHT NON-FERROUS METAL ALLOYS

(June issue of THE JOURNAL, p. 636)

(13) ALUMINUM ALLOY SPECIFICATIONS

(June issue of THE JOURNAL, p. 637)

(14) SOFT OR ANNEALED COPPER WIRE

(June issue of THE JOURNAL, p. 637)

PARTS AND FITTINGS DIVISION REPORT

(15) FLARED-TYPE TUBE-FITTINGS

(June issue of THE JOURNAL, p. 627)

THE DISCUSSION

WALTER C. KEYS:—I move that the report of the Parts and Fittings Division, with the exception of that part relating to Compression-Type Tube-Fittings, be approved by the Standards Committee.

[The motion was seconded]

MR. BACHMAN:—The list of stock sizes of the flared-type tube-fittings includes nine stock sizes that could just as readily be reduced to five, and I question whether the sixteenth-inch sizes are not bad from a wrench standpoint.

MR. KEYS:—That point was considered thoroughly in the Division meetings at which we had representatives of practically all the manufacturers of these fittings, and they finally agreed on this report.

VICE-CHAIRMAN CARLTON:—We are omitting from this discussion all reference to the compression-type tube-fittings. Is there other discussion?

[Mr. Keys' motion was put to a vote and carried]

(16) SOLDERED-TYPE TUBE-FITTINGS

(June issue of THE JOURNAL, p. 628)

The column headings "max." and "min." in the table for nuts were reversed as a correction.

(17) COMPRESSION-TYPE TUBE-FITTINGS

(June issue of THE JOURNAL, p. 628)

This report was referred to the Council for disposition in connection with a general study to be made by the Council of the policy to be followed in standardization projects in which patents may be involved.

THE DISCUSSION

MR. KEYS:—I move that the report on the compression-type of fittings be approved as recommended practice subject to final approval by the Council of the Society.

[The motion was seconded]

PRESIDENT CRANE:—Personally I would oppose moving this report through the usual routine until such time as the patent situation is absolutely and definitely agreed to by contract. I do not think there is any necessity for the Society proceeding fast or faster than the rest of the organizations interested in this subject do.

As to whether this report should go through this meeting and have it held up by the Council, I should say it would be much better to let it stay in the Division until such time as the patent situation is straightened out. The Council has practically unanimously decided that the Society will not intervene in patent situations such as this, or have anything to do with making contracts of this kind. The business end of such matters will have to be carried through by the accessory manufacturers or the National Automobile Chamber of Commerce.

MR. BACHMAN:—There is another angle to this phase of the matter that Mr. Crane outlines which the members of the Committee ought to bear in mind as they are voting on this proposition. As a member of the Society's Patents Committee, I have had to consider several subjects similar in nature to this one. Fittings of this sort are in more or less common use and as such it may be desirable to have standard sizes. Whether listing sizes or dimensions of an article that is patented constitutes an acceptance of the device in an ordinary sense from a patent standpoint is questionable.

It may be that a note or warning clause should be printed in connection with the report, although this may not be conforming to the policy that has generally been followed in Standards work. I am not sure, however, that this is a necessarily correct policy.

MR. KEYS:—The motion as I stated it would only pass this report through the Standards Committee, and the Council could then consider it with regard to the policy to be followed. I think that if we can approve the dimensions today in the Standards Committee they will have become pretty well established in a year or so. I therefore feel that the motion should be supported, and the matter of policy left to the Council.

A. J. SCAIFE:—At present there are several different types of fitting, this being one. We are not recommending these dimensions as standard, but we are trying to establish them as recommended practice or possibly general information. Inasmuch as this general type of fitting is being used by the industry, I believe it is advisable to publish something possibly with a protecting paragraph, instead of having no specifications at all.

PRESIDENT CRANE:—I am glad Mr. Bachman brought the subject up in the way he did. My attitude and that of the Council have been based solely on our practice in the past. With regard to the patent situation, I feel much the same as Mr. Bachman does. I think that where parts, even of a supposedly patented article, are used we might get their specification into the S.A.E. HANDBOOK in some form in order to try to simplify the product so far as we can.

What I am opposed to in this case is passing the report with any string attached to it as to the patent situation. I think we should either do it with our eyes open and let the patent situation take care of itself or if we think that the patent situation is controlling, we had better wait until it is straightened out. It may be that the whole matter ought to be referred to the Constitution Committee or some other committee to revise our rules regarding standardizing patented articles and that we should be a little freer about using information of that kind, and have some form of pre-

sending it in the S.A.E. HANDBOOK that would cover the case. This would get such information to the members of the Society without involving any arguments or discussion regarding patents.

MR. KEYS:—While patents on this type of tube fitting are held by the Imperial Brass Mfg. Co., it is being manufactured by numerous competitors apparently without regard to those patents, the implication being that the patents are considered either not strong or perhaps that they are simply a matter of protection against attack from someone else. This company has signified its willingness to meet everybody more than half way on this phase of the subject.

MR. CRANE:—If the patent situation is in such a state that these fittings are being freely made by other manufacturers we certainly do not want to become involved. We had better forget all about the patents and put the report in the S.A.E. HANDBOOK just on its merits as information. I am perfectly willing to abide by either policy, but I would like the two policies kept perfectly distinct. Either we want to press the National Automobile Chamber of Commerce to complete the patent arrangements now being negotiated before we do anything, or else consider that it makes no difference whether they do so.

R. A. BRANNIGAN:—I might say that the Chamber and the Imperial Brass Mfg. Co. have arranged, if the Society wishes it, to sign a contract that will bring about this result. The fact that the consideration is only \$1 shows that the patents are of negligible value. If the Society standardizes this article and people use it without entering into this or some contract, the Imperial Brass Mfg. Co. can at any time sue them. Perhaps it never will sue, but by entering into the contract you are exchanging possible litigation for assured peace for the price of \$1.

MR. CASE:—I suggest as an amendment to the motion, that this report be approved in the regular way, without any allusion to the patent situation. It seems to me that it would be unfortunate for the Society to be in the position of ruling out a meritorious device simply because it is patented, especially where other similar devices are standardized as in this case.

VICE-CHAIRMAN CARLTON:—We have a definite motion to adopt this report as it stands, with the recommendation that it be referred to the Council for final disposition. Is there any further discussion before we take a vote?

PRESIDENT CRANE:—We have printed with the report the statement, "The recommendation proposed by the Division is therefore made with the proviso that the patent situation shall be cleared before the recommendation is acted upon by the Standards Committee." We have a motion now that requires action by the Standards Committee. Just what is the motion before us?

[The motion by Mr. Keys was read]

MR. BACHMAN:—The motion is nothing more than the following of our regular practice. Is that what Mr. Keys meant when he said, "subject to final approval of the Council" or did he mean something else that he did not fully state?

MR. KEYS:—What is meant, is first, that we are to act on approving the details of this report, giving all the dimensions that may be required for any one to produce fittings that will interchange; and, second, that after the detailed report has been accepted by the Standards Committee, the policy of what shall be done with the

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report should be decided by the Council, which has full authority in this matter.

MR. CRANE:—I am satisfied with that arrangement because I think it is desirable perhaps to review the question of policy in matters of this kind. The Council, the Standards Department and probably the personnel of the whole Standards Committee may, in the next 6 months, be able to work out some way in which we can do this sort of thing better than we have done it in the past. I think the Council should look into a revision of the policy of the Society as regards standardizing matters of this kind in which a patent situation is more or less directly involved.

MR. BURNETT:—The Division made this recommendation with the proviso that an agreement between the Imperial Brass Mfg. Co. and the National Automobile Chamber of Commerce be consummated. This subject was considered by the Council for decision as a matter of policy before the Division made its recommendation.

My last minute information is that the Imperial Brass Mfg. Co. will sign this agreement prepared by the National Automobile Chamber of Commerce. It may be signed by this time, but we have no signed copy in our possession.

VICE-CHAIRMAN CARLTON:—Are you ready to vote?
[The vote was taken and the motion was carried]

(18) PASSENGER CAR BUMPER MOUNTINGS
(June issue of THE JOURNAL, p. 628)

(19) WIRE CLOTH
(June issue of THE JOURNAL, p. 629)

SCREW THREADS DIVISION REPORT

(20) HIGH NUTS
(June issue of THE JOURNAL, p. 638)

THE DISCUSSION

MR. CASE:—I move that the Report of the Screw-Threads Division be approved.

[The motion was seconded]

A. BOOR:—Why are the depths of the slot for the high nuts not the same as those for regular S.A.E. castellated nuts? We have a standard for regular nuts that is satisfactory, and it seems to me we should apply it to this particular nut. Also, the counterbore of the plain nuts removes about 25 per cent of the thread, which reduces appreciably the strength of the nut. An extra-deep nut with practically full-length thread has an advantage in many places where an alloy-steel bolt is used.

MR. CASE:—The depth of slot was worked out by Mr. Ehrman and then acted on by the Division, but I cannot tell offhand just now how it was worked out. As I remember, the depths of the slots in the regular standard nuts are not altogether consistent, and they were made consistent. I am not familiar enough with the punching of slots in castellated nuts to know whether the same tools could be used for them that would be used for regular nuts if they had the same slots, or whether the nuts are sufficiently different to require different tools.

MR. BURNETT:—As a matter of information, I think that this report on high nuts is in some respects looking toward what will possibly be done by the Sectional Committee on Bolt, Nut and Rivet Proportions, which committee's work may have an influence on the present S.A.E. standard nuts and bolt-heads. The sectional committee is a large one representative of practically all major industries interested in these products. It is

sponsored by the American Society of Mechanical Engineers and this Society, and operates under the rules of procedure of the American Engineering Standards Committee of which the Society is a member body. I think Mr. Ehrman has tried to anticipate such changes as may later be desirable in the present S.A.E. and other standards and has incorporated them into this report.

There are a few other points in connection with this report that Mr. Ehrman has suggested since this report was printed. They are that a tolerance be placed on Dimension *E*, the diameter of the flat across the top of the nut, equal to plus 0 minus 8 per cent of the diameter; that the maximum height of the washer face of the nuts be equal to $\frac{1}{4}$ of the bolt diameter throughout the entire series of sizes; that, if desirable, a chamfer of 30 or 35 deg. be placed at the bottom of the counterbore, and that the counterbore be specified as optional but not regular; and that the angle of the chamfer on the top of the nut be 30 deg.

PRESIDENT CRANE:—The question of threading these nuts for their full length brings to mind the question of thread lead. It is hard enough now to get the thread lead right for a full-length bearing in regular S.A.E. nuts and it is obviously no use having a long thread in a nut unless the threads of the nut and bolt have a correspondingly reasonably close fit. A long nut is much handier to use if it is counterbored enough to require relatively few turns to get it on or off.

MR. CASE:—The manufacture of ground taps has been developed sufficiently so that today they can be used for fine work without greatly increasing the expense. I have been told that on some of the larger sizes, at least, it is more economical today to use ground taps. At any rate, the difference in cost is not very great and, if the more exact lead is called for on a long thread, I think it can be obtained without difficulty and that it will be perfectly proper to standardize it.

Since some question regarding the counterbore has arisen, I would suggest that this report be approved as printed, to establish the basic dimensions as soon as we can, because they are of real importance to the manufacturer.

Any user wanting nuts in quantities without the counterbore, or other detailed changes for particular purposes, can get them. The changes just suggested are in the nature of additional details that can be taken up by the Division for modification next year.

A. M. WOLF:—Was the dimension *C*, the height of the nut, considered with reference to spring-clip nuts which are $1\frac{1}{2} D$? We should have one standard for the two purposes.

MR. CASE:—That spring-clip nut apparently is not being used very much at present.

MR. WOLF:—I believe some people are using it.

MR. BOOR:—It would not fit in with our practice.

MR. CASE:—Our investigation showed that these nuts are being made in a number of different thicknesses and our recommendation was based largely on an average of these thicknesses for each size that is now being made, with the idea that the proposed dimensions would do away with the many present sizes. It may be necessary to have the still higher or thicker nut for spring clips.

MR. BOOR:—I question whether the two can be combined, because, in the case of the high nut, if it is used inside an engine, the clearances would very often be limited. We have instances where this nut would go, but the $1\frac{1}{2}$ diameter nut would not go.

[The vote was taken and the motion carried]

(21) DIMENSIONAL TOLERANCES
(June issue of THE JOURNAL, p. 638)
SPRINGS DIVISION REPORT

The report of the Springs Division was modified by action taken by the Division at a meeting held the evening prior to the Standards Committee Meeting, the modifications being given following each subject of the report.

(22) MOTOR-TRUCK SPRINGS
(June issue of THE JOURNAL, p. 639)

The revised report recommending cancellation of this present S.A.E. Recommended Practice was approved.

(23) PASSENGER-CAR SPRINGS
(Additional report not published in June issue of THE JOURNAL)

Cancellation of this present S.A.E. Recommended Practice was approved.

At the meeting of the Division just prior to the Standards Committee meeting it was decided to revise the report on Motor-Truck Springs by recommending its cancellation because of its non-application in practice. An additional report recommending cancellation of the present S.A.E. Recommended Practice for Passenger Car Springs, p. H-8 of the S.A.E. HANDBOOK, was also voted for the same reason and so as to have the S.A.E. HANDBOOK consistent with regard to these two subjects.

THE DISCUSSION

W. E. DUNSTON:—The Springs Division recommends that the present recommended practices for both truck and passenger-car springs printed on pp. H8 and H9 of the S.A.E. HANDBOOK be eliminated instead of making the change that is suggested in the report.

(24) LEAF-SPRING STOCK
(June issue of THE JOURNAL, p. 639)

The following modifications in the report were made: Cancel the 2 x No. 5, 2 x No. 6, 2 1/4 x No. 5, 3 x No. 2 and the 4 x 5/16 stock sizes and add the 3 1/2 x 7/16, 3 1/2 x 3/8 and the 3 1/2 by 5/16 stock sizes.

THE DISCUSSION

MR. DUNSTON:—In the proposed specification for Leaf-Spring Stock dimensions, the Division has modified the table by eliminating the following sizes: 2 x 5, 2 x 6, 2 1/4 x 5, 3 x 2 and 4 x 5/16 gages; and by adding the following sizes: 3 1/2 x 7/16, 3 1/2 x 3/8 and 3 1/2 x 5/16 gages.

It was felt that these sizes that are eliminated are used so little that it should not be called a standard.

(25) LEAF-SPRING DEFINITIONS
(June issue of THE JOURNAL, p. 639)

In the definition of "Load" add "at the center of the spring seat" after the word "spring" in the first line.

In the definition of "Spring Height" add "axle" before the word "spring-seat" in the second line.

In the definition of "Flexibility" add the word "average" before the word "number" in the first line.

THE DISCUSSION

MR. DUNSTON:—In connection with the proposed Leaf-Spring Definitions, several criticisms were considered that lead to the following changes:

Under the definition of Load, the first sentence is changed to read, "The number of pounds to be carried by the spring at the center of the spring seat."

Under "Spring Height," the first sentence was changed to, "The normal distance from a line through the center of the spring-eyes to the face of the axle spring-seat at its center," the word "axle" being added.

Under "Flexibility," the wording was changed to read,

"The average number of pounds" instead of "The number of pounds."

MR. KEYS:—In the case of cantilever springs, how would the definition for spring height apply?

MR. DUNSTON:—In several cases the definition would not apply, but I believe that is taken care of at the beginning of the report where it says, "The definitions are intended primarily to apply to the conventional semi-elliptic type of automobile springs."

(26) LEAF SPRING NIBS

(June issue of THE JOURNAL, p. 639)

(27) SPRING OFF-SETS AND RESULTING ENDS

(June issue of THE JOURNAL, p. 640)

(28) LEAF SPRING TESTS

(June issue of THE JOURNAL, p. 640)

The second and third sentences of the first paragraph of the specifications and the illustration of the Cantilever Spring Compression-Test Support were deleted.

LEAF-SPRING TESTS

THE DISCUSSION

MR. DUNSTON:—Under the proposed S.A.E. Standard for Leaf-Spring Tests, all after the first sentence was eliminated from the first paragraph. The illustration of the Cantilever Spring-Test Support at the bottom of p. 640 was also left out. I move that the report be approved as changed.

[The motion was seconded]

MR. SCAIFE:—With reference to the illustration for the quarter-elliptic spring on a caster carriage, the method of testing is not similar to the actual operation of the spring in service. For instance, a spring of 1000 lb. per in. for 7 in. will be about 1000 lb. per in. for the 7 in. or the same amount for each inch, but when the carriage slides out and the spring arm becomes longer, the pressure per inch becomes less. Therefore, the method of measuring that type of spring is not the same as when the spring is mounted.

MR. DUNSTON:—The Division has given these tests for the more conventional types of spring and that question was brought up. I think the slipper type of spring would be a special case that would have to be worked out specially.

[The vote was taken and the motion carried]

ATTENDANCE AT MEETING

The members of the Standards Committee and the Society and the guests in attendance were

Standards Committee Members

Azel Ames	J. H. Hunt
B. B. Bachman	W. C. Keys
C. E. Banta	J. A. Kraus
A. Boor	G. L. Lavery
T. V. Buckwalter	W. A. McKay
R. S. Burnett	C. A. Michel
C. C. Carlton	P. R. Moffett
G. S. Case	Leonard Ochtman, Jr.
C. F. Clarkson	O. F. Ostby
H. M. Crane	L. C. Porter
R. N. Falge	T. D. Pratt
W. E. Gossling	C. D. Ryder
A. W. S. Herrington	A. J. Scaife
S. P. Hess	H. W. Sweet
C. E. Heywood	E. E. Wemp
F. G. Hughes	F. G. Whittington

Society Members and Guests

R. A. Brannigan	H. Thurston Owens
J. H. Burroughs, Jr.	A. P. Palmer
W. L. Carver	J. R. Reyburn
F. H. Colvin	C. F. Scott
A. W. Deyo	J. S. Simonds
R. S. Ellis	P. E. Stone
J. B. Entz	G. E. Strohm
A. H. Hoffman	E. B. Sturges
B. B. Holmes	J. C. Talcott
W. H. Hutchins	G. B. Trodell
H. M. Martin	G. A. Tyler
W. C. Munson	W. G. Wall
S. W. Nicholson	E. P. Warner
C. L. Norton	A. M. Wolf
H. H. Oetjen	W. C. Wolfe

TENTATIVE STANDARDIZATION WORK

Criticism of all tentative reports
should be sent to the Standards
Committee in care of the Society

OIL SPECIFICATIONS ADOPTED

One of the larger manufacturers of lubricating oils recently sent a general letter to the manufacturers of passenger-cars and motor trucks requesting information as to the grades of oil recommended for the different car and truck models. The fact that the present S.A.E. numbers for crankcase lubricating oil specifications were used by the greater number of manufacturers is of interest in showing that the Industry has adopted in actual practice the S.A.E. Recommended Practice for Crankcase Lubricating Oils developed by the Lubricants Division in March, 1923, and printed on p. G151 of the S. A. E. HANDBOOK.

TO EXTEND LEATHER SPECIFICATIONS

A general letter has been sent by the Society to body builders, including passenger-car manufacturers making bodies, asking for recommendations as to how the present S.A.E. Recommended Practice for Upholstery Leather can be extended to make it of more value to the industry. The present specifications do not permit the patching of grub-holes and other defects, yet K. L. Herrmann in his paper on leather presented at the Annual Meeting estimated that such patching would save the industry \$2,000,000 yearly. Information as to the experience of the industry on the following points is desired:

- Difficulties of applying the present S.A.E. Specifications on Upholstery Leather to present production
- Recommendations for changes in testing the strength of leather
- Recommendations concerning specification for patching
- Recommendations on leather flexibility requirements
- Recommendations as to the number of coats of material to be used
- Recommendations on methods of testing coatings for wear, color, luster, cracking and spawling
- Recommendations on embossing-plate standardization

PROPOSED LAMP-DOOR CONSTRUCTION

Subdivision Criticized for Not Recommending Bayonet Type of Construction

One of the subjects that has been under consideration by the Lighting Division is the development of specifications recommending what is considered good engineering construction for head-lamp doors insofar as closing and fastening is concerned. A Subdivision, of which B. M. Smarr, of the General Motors Corporation, is chairman, the other members being C. D. Ryder, of the Cincinnati Victor Co.; W. F. Thoms, of the Indiana Lamp Co.; H. H. Oetjen, of the Edmunds & Jones Corporation; H. M. Lucius, Maryland State Board of Motor Vehicle Inspection, and G. P. Doll, of the Thomas J. Corcoran Lamp Co., submitted the following report at the Lighting Division meeting in Detroit on April 28:

It is recommended that the lamp door be assembled to the body in connection with the reflector by exerting a force in a direction parallel to the axis of the lamp. The force required to assemble the door is to be maintained as compression on the sealing material by a

convenient locking device, such compression to be set or released from the outside of the lamp by a mechanical device that will remain assembled to either the lamp, the door or the lock-ring, when the compression is released.

While the above general type of door construction is recommended, certain forms and combinations of materials making up what is commonly known as the bayonet door-lock are recognized as making an easily accessible door and it is recommended that as long as this type of construction is used, one of the metals at each point of contact between two metals, where there is an abrasive action, be a non-ferrous metal.

After considerable discussion the Division voted to retain the first paragraph of the Subdivision's report, to omit the second paragraph, and to add the following:

Suitable means shall be provided in the lamp construction to prevent the lamp glass from falling from the part to which it is assembled, when the lamp is opened.

At the time the accompanying recommendation was considered by the members of the Lighting Division, it was felt that the bayonet type of head-lamp door construction should not be recommended, but that a satisfactory specification may be recommended in the future for improved designs of this type of construction or when the door and lamp parts in contact with each other are made of non-ferrous or non-corroding material.

The action of the Division was criticized adversely after the meeting and the report was, therefore, withheld. To get a more general expression from the lamp and car-manufacturing industries regarding this subject, a general letter was sent to each lamp and passenger-car manufacturer requesting the following information:

- Opinions regarding the recommendation
- Information as to experience in using head-lamps with bayonet type of door construction
- Attitude with regard to using this type of construction

Whether a recommendation should be adopted by the Society either for or against such a specification

Suggestions as to what such a specification should be

Information obtained from the manufacturers is to be referred to members of the Subdivision and further action based thereon.

SPECIAL HAND-CRANKS UNDESIRABLE

Used Only in Emergencies and Should Be Generally Interchangeable

The reason why automobile manufacturers do not make hand starting-cranks interchangeable has been questioned by one of the members of the Hoover Committee on the Elimination of Waste. In a letter written to the Division of Simplified Practice this member makes the following comments:

I suggest that you look into the possibility of standardizing hand starting-cranks for passenger cars. Now that practically all cars are equipped with electric starting devices, one only needs to use the hand starting-crank at rare intervals. I have used mine only

once in 4 years. This was a few days ago when my starting-motor broke down and I found that in the nearby village of 5000 people, having possibly 10 garages, not a single starting-crank would fit my machine. The engine was therefore started by towing the car. Yesterday I went to the dealer's service-station and had to try three starting-cranks before I got one that fitted. I paid \$1.60, and perhaps this will be the only time I will use this particular part during the life of the car.

There is certainly nothing individualistic about starting-cranks and it is difficult to see why passenger-car manufacturers would not agree to use one of two or three sizes of standard starting-cranks. S. F. Evelyn, of the Engine Division, is at the present time revising the present standard for hand starting-cranks and it is hoped that his work will result in the adoption in future practice of a limited number of starting-crank sizes.

BRAKE-DRUM STANDARD UPHELD

Manufacturer Says 95 Per Cent of Cars Will Use Low-Carbon Brake-Drums

Considerable correspondence has recently been published in trade papers to the effect that the present S.A.E. Standard for Brake-Drums, p. F1f of the S.A.E. HANDBOOK, which was adopted by the Society in February, 1924, is based on the use of the material that is not suitable for brake-drums and will not be used in the future to any extent. The following extracts are taken from a letter received by the Society from an engineer connected with a manufacturer of brake-drums and indicates that, as stated in the Standards Committee Meeting in January, a low-carbon steel brake-drum will be used to a considerable extent.

It is admitted that when a brake-drum is made of 0.40 to 0.50 per cent, or higher, carbon, it is impossible to hold the plain stamping to the limits recommended and the only way to obtain them is by machining the drum. A high-carbon drum will, undoubtedly, give better service than one made of ordinary low-carbon pressing-quality steel, but the use of it is limited to high-priced cars only, the manufacturers of which can afford to spend additional money to make the braking mechanism as perfect as possible. The company I am connected with has had many inquiries relative to high-carbon drums from automobile manufacturers who would gladly install them on their cars if it were possible to purchase them at the same low cost as low-carbon drums. I am positive that 95 per cent of the cars produced will continue to use low-carbon drums. In this case the S.A.E. Recommended Practice should be for the majority rather than for the minority.

We have also found that drums can be formed without machining, to the limits specified in the recommendation; and it is known that when the drum is pushed through the dies the outer surface or skin is hardened somewhat and will resist wear much better than it would if a cut were taken off, thus exposing the softer material. This also applies to high-carbon drums, but it is necessary to machine them to obtain the required concentricity.

The recommended dimensions do not consider flanged

brake-drums which under certain conditions should be used, but these drums would come under the same category as high-carbon drums and it should be left to the individual manufacturer to decide upon the limits and stock thickness.

In other words, it is impossible to have recommended sizes that will cover the field 100 per cent, and the only thing we can do is to make them so that they will apply to the majority of cars. Undoubtedly, the sizes decided upon by the Subdivision were made with this point in view.

I do think, however, that the wall height or width of the brake-drum should be specified. At the last Standards Committee Meeting someone stated that it would not be necessary to have definite heights given due to the fact that the brake-drum manufacturers draw the side-wall considerably higher than is necessary and trim it to the proper height. This is true and yet it is not, because for the last 2 or 3 years competition has not allowed the manufacturer to use a larger blank than is absolutely necessary. In other words, each drum is made so that there is just sufficient stock to trim off to give the proper height, and a drum 2¼ in. high would be made from a blank smaller than that used for a drum 2½ in. high.

Therefore, I think it would be advisable to have certain specified heights for each diameter of drum so that the manufacturer could buy plates of the proper widths. It would not take long to ascertain just what widths to carry in stock. In this way he would be able to make quicker delivery on standard drums.

S.A.E. STANDARDS USED IN OIL INDUSTRY

The following is extracted from a letter from Harry Pennington, a mechanical engineer in Houston, Tex., who recently obtained a copy of the S.A.E. HANDBOOK.

In designing hydraulic rotary equipment for drilling oil wells and for pumping, I have been using four and six-cylinder engines and transmissions. The engines are purchased without accessories and we make the flywheel housings and purchase the carbureters, magnetos, fans and other accessories separately.

On all drawings received S.A.E. Standard practice is specified for flanges, bolt-circles, steels, splines, gears and other details, and I find that it is necessary to use the S.A.E. HANDBOOK.

The oil industry, through the American Petroleum Institute, is now engaged in standardizing equipment of all kind. The work done by the Society has furnished us steel specifications and practices that are of great value, especially in interchangeability of parts.

I hold that your Society's work is the best example of standardization and take this means of advising you that, outside of the Society, the work is greatly appreciated.

The standards especially mentioned by Mr. Pennington have been in existence so long that they are now taken as a matter of course by the automotive engineers and their real value is not appreciated. Such comments as those quoted above make it easier to appreciate the correctness of the 15-per cent estimated saving in the production cost of automotive vehicles, which was based on an analysis of estimates made by 146 engineers and executives submitted to the Society in 1921.



Testing of Air-Cleaners

By A. B. SQUYER¹

SEMI-ANNUAL MEETING PAPER

Illustrated with DRAWINGS AND PHOTOGRAPH

A GOOD air-cleaner is an essential part of automotive engine equipment. Many types of cleaner are on the market and the user must choose on the basis of the three essential requirements of maximum cleaning efficiency, minimum attention from the operator and minimum power-loss.

With respect to these three essentials, the development of a laboratory method of testing air-cleaners starts with the premise that the test for efficiency should consist of feeding in a weighed quantity of dust, and an account be made for that which is not separated by the cleaner. The first method was to insert a white outing-flannel cloth in the airstream from the cleaner. The varied degrees of soiling of the cloths from different cleaners were a relative measure of their efficiency. This method was found unsatisfactory for several reasons.

An attempt was made to use a dry centrifugal cleaner of predetermined efficiency, in series with the cleaner under test, to catch a portion of the dust escaping. It was found, however, that the efficiency of the centrifugal cleaner varied with the fineness of the dust, and that the dust escaping another cleaner was so fine that almost none of it was caught by the centrifugal cleaner.

It was discovered that soft felt $\frac{3}{8}$ in., or more, thick was 100-per cent efficient when used as a filter. A filter was arranged using soft felt $\frac{5}{8}$ in. thick interposed in the air line from the cleaner under test to the carbureter. The filter was arranged so that the felt could be removed and weighed. In making a test, the apparatus was set-up, using an air jet for suction instead of an engine. A venturi meter was inserted in the line to assure correct air velocity. The apparatus was operated without feeding dust until the weight of the felt became constant. Then, 50 grams of dust was fed into the cleaner and, from the increase in weight of the felt filter, the efficiency of the cleaner was computed. The best cleaners, as determined by this method, were then checked by the use of an engine under load on a Sprague cradle-dynamometer. Determinations were made also of the cleaner's effect on the horsepower of the engine, as well as of the water consumption of washers, or any other factors that might affect the operation of the cleaner or engine.

While it is possible and may appear feasible to some to embody more refinement in the method outlined, the author believes, due to his experience and observation, that this is not essential to the determination of a satisfactory air-cleaner. In making the final choice, the most efficient cleaner may not be selected. Operators do not, as a rule, give the necessary attention to such auxiliary apparatus. If a cleaner requires little or no attention from the operator, it might be the wiser choice even though it may be slightly less efficient. In cases where tractors are called upon to operate under extremely dusty conditions, it has been found advisable to combine a centrifugal cleaner, which requires no attention, with an oily fiber filter. This combination gives an overall efficiency of 99.9 per cent and the filter need only be cleaned and re-oiled once a week.

The method of attachment to the engine is very important, in that tight connections must be provided so that unclarified air shall not leak into the carbureter

inlet. The author recommends standard flange connections, or their equivalent, throughout.

IT is becoming recognized more and more by manufacturers, distributors and users of automotive apparatus that a satisfactory means of cleaning the air entering the engine is imperative. Especially is this true of tractors. These implements are, more often than not, called upon to operate under conditions where the air is extremely dust-laden. It is not necessary to emphasize the injurious effect of dust on the engine. It has been stated by reliable authority that engines operating under extremely dusty conditions, with no air-cleaner, have had their normal useful life reduced to 15 hr. As a result of this necessity, many types of air-cleaner are on the market. Some tractor manufacturers have devised and manufactured their own cleaners. The types range from dry centrifugal cleaners, in which the dust is separated from the air by the centrifugal action set-up by the air being caused to whirl rapidly, through the water washers, oil washers, dry filters and periscopes, to various combinations of two or more of these. The problem confronting the automotive manufacturer who contemplates using such apparatus is to choose that which will best meet his requirements.

Three things are required of a good air-cleaner; maximum efficiency, the minimum of attention from the operator and the minimum power-loss to assure satisfactory operation. The development of laboratory methods to determine the relative values of various air-cleaners as such, especially the first requirement, maximum efficiency, is the subject of this paper.

DEVELOPMENT OF TESTING METHODS

In the summer of 1921 I was confronted with the problem of devising a satisfactory method of conducting efficiency tests on air-cleaners of all types. Cleaners were submitted by manufacturers to be passed upon. In many instances representatives called with their cleaners and their own testing apparatus and conducted their own tests in our presence. In no two cases of this kind were the methods used for test the same, nor was the dust used known to be of the same nature or consistency. Therefore it was impossible to make a true comparison as to the relative cleaning capabilities of any two or more cleaners tested under these circumstances. Accordingly, to make true relative comparisons, it became necessary that all cleaners be subjected to the same method of test. With this idea in mind, I set out to devise a method that would give the results sought.

It became evident early in the development of these tests that the method used would have to take account of the dust not caught by the cleaner. Inasmuch as some cleaners caught and retained the separated dust in a dry state, some retained it in water, some in oil, others in a dry or oily filtering medium and still others ejected it back into the atmosphere, it was obviously out of the question to attempt to account for the separated dust. This left open a method that accounted for the dust

¹ Research engineer, Holt Mfg. Co., Peoria, Ill.

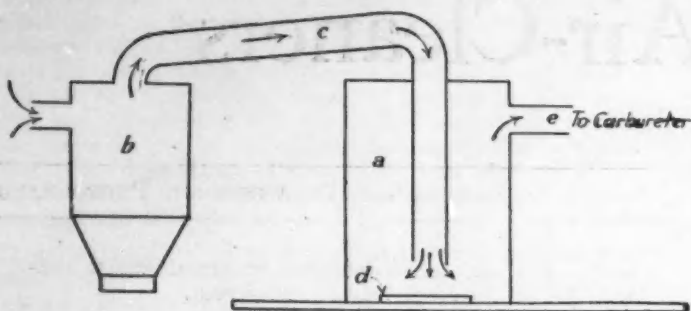


FIG. 1—SET-UP FOR RELATIVE TEST OF AMOUNT OF DUST THAT ESCAPES THE CLEANER

In This Test the Air from the Cleaner *b* Was Passed through the Tube *c* to the Sheet-Metal Chamber *a*. At the Bottom of the Chamber a Disc, *d*, of White Outing Flannel Was Placed So That the Air Entering from *c* Would Impinge upon It and then Pass on to the Carburetor through the Tube *e*. The Cleaner Removed a Portion of the Dust in the Air Entering the Cleaner and the Remainder Was Thrown with Some Violence against the Disc and Soiled It. The Relative Soiling of the Discs Was Taken as a Relative Measure of the Cleaning Qualities of the Cleaner

escaping the cleaner. In pursuance of this method it was decided at first to use a relative test.

A RELATIVE TEST

An arrangement was constructed as shown in Fig. 1. A sheet-metal chamber, *a*, was mounted in such a way that the air from the cleaner *b* passed to the chamber through a connecting tube, *c*. At the bottom of the chamber *a* a white-outing-flannel disc, *d*, 4 in. in diameter, was placed so that the entering air would impinge upon it as shown. The air went from the chamber *a* through the tube *e* to the carburetor. A four-cylinder engine of 4¾-in. bore and 6-in. stroke was mounted on a Sprague cradle-dynamometer for these tests. It developed about 45 hp. at 1000 r.p.m. A weighed quantity of dust, which previously had been sifted through a 200-mesh sieve, was fed at a uniform rate. The cleaner removed a portion of this dust; the remainder, going on through the tube *c* in to the chamber *a* and being thrown rather violently against the white-outing-flannel disc, soiled it. The relative soiling of the discs was taken as a relative measure of the cleaning qualities of the cleaner. At the completion of a series of tests, the discs, which had been carefully stored in air-tight containers, were photographed.

The results of this method are shown in Fig. 2. No. 1 is the result obtained when no cleaner was used. The white strips across the face of the discs are clean white flannel to contrast the soiling. Finely powdered charcoal was used for dust, as it exhibits very marked soiling qualities. Nos. 5 and 6 are of the same cleaner. In test No. 5, 25 grams of dust was fed in 15 min. In No. 6 the same amount was fed in 10 sec. It serves to show that some types may be more efficient when fed rapidly than when fed more slowly. Feeding was tried at slower rates up to 2 hr., however, without any change in efficiency that could be detected. No. 8 is a cleaner of the water-washer type. It is mentioned because of the several dense black spots appearing. These were wet when the disc was removed from the chamber, thus proving that this particular make of cleaner does carry over small slugs of water heavily laden with dust. No. 7 is also a water washer, but this fault is not evident from observing the test disc.

After giving this method a thorough trial, however, it was found to have many shortcomings. The test discs were often so near alike as to make it questionable which was the better of the two. Moreover, the publishing of

results was difficult, as was also the ability of another person to secure the same results. Duplicating the result proved to be difficult unless the identical apparatus was used. The outing-flannel cloths must always be of the same texture. The chamber *a* must always be exactly the same dimensions, and the tube *c* must always be exactly the same distance from the flannel disc. For these reasons a more positive method of test was desirable.

ANOTHER TESTING METHOD TRIED

A cleaner of the dry centrifugal type was tested as follows: The cleaner was connected to the engine carburetor and 100 grams of dust was fed slowly. The dust retained by the cleaner was weighed. Eighty-six grams was recovered. This cleaner's efficiency was therefore taken as 86 per cent. Two of these cleaners were then connected in series. The efficiency of each being 86 per cent, their combined efficiency should be 98.04 per cent; that is, the second cleaner should catch 86 per cent of the 14 grams that escaped the first cleaner, or 12.04 grams, which, added to the 86 grams caught by the first cleaner, gives 98.04 grams. It was intended to use this cleaner in series with any cleaner that it was desired to test. The dust it caught could be weighed and, from its known efficiency of 86 per cent, the efficiency of the first cleaner could be computed. However, only 87.4 grams was recovered from the two cleaners in series. The dust that escaped the first cleaner was so fine that it escaped the second also. It was evident that an absolutely 100-per cent efficient cleaner must be obtained to catch all the dust that escaped the cleaner under test.

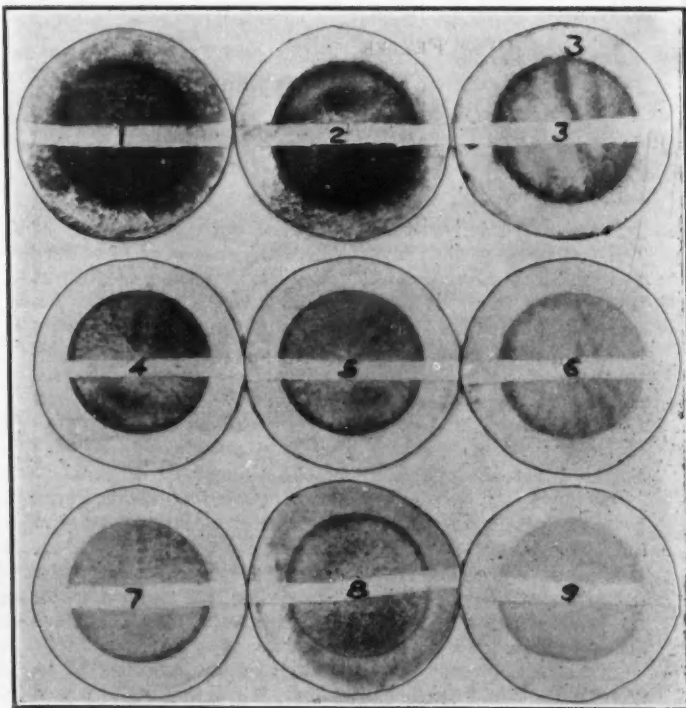


FIG. 2—TEST DISCS OBTAINED FROM THE RELATIVE TEST
The White Strips across the Face of the Discs Are Clean White Flannel To Contrast the Amount of Soiling. Disc No. 1 Was Obtained without any Cleaner with Finely Powdered Charcoal for the Dust Because Its Soiling Qualities Are Very Marked. Discs Nos. 5 and 6 Were Obtained with the Same Cleaner, 25 Grams of Charcoal Dust Being Fed in 15 Min. in the First Instance and in 10 Sec. in the Other. A Comparison of These Discs Shows That Some Types of Cleaner May Be More Efficient When Fed Rapidly Than When Fed More Slowly. Discs Nos. 7 and 8 Were Obtained with a Water-Washer Type of Cleaner. In the Case of the Latter the Black Spots Shown Were Wet When the Disc Was Removed from the Chamber, Proving That This Particular Make of Cleaner Does Carry Over Small Slugs of Water That Are Heavily Laden with Dust

After much painstaking study of materials, including vacuum-cleaner bags, eiderdowns, multi-layer muslins and, in fact, nearly every conceivable form of fabric strainer or filter, it was decided to use felt as a filter. It was discovered that soft felt, of S.A.E. Specification No. F26, and $\frac{3}{8}$ in. or more thick, was 100-per cent perfect as an air-cleaner for the practical purposes of this test.

METHOD FINALLY USED

The final set-up was made as shown in Fig. 3. Here the air enters the cleaner under test, and the dust is blown in, in a fog, by the feeder. From the cleaner the air passes through the $\frac{5}{8}$ -in. felt in the double funnel. The edge of the inside funnel is drawn in so that it clamps onto the felt and all the air must pass through the felt. The suction is caused by an air jet as shown, instead of by using an engine. It was found by trial that the results were practically the same with this method as when using an engine, although after, by a process of elimination, the choice was narrowed down to two or three of the best cleaners, the final tests were made while using an engine.

The venturi meter and U-tube manometer were used to assure correct air-velocity. The meter was constructed especially for this purpose. It was first attached to the carburetor inlet of an engine and manometer readings were taken for idling, one-quarter, one-half, three-quarter and full loads. In the tests the air jet was then adjusted to secure corresponding readings of air-velocity. All cleaners submitted for test were first tested at full-load air-velocity. The best of these were then tested at idling, one-quarter, one-half, three-quarter and full-load velocities.

DUST FEEDER AND DUST USED

The dust feeder consisted of a funnel large enough to hold 50 grams of dust. This funnel was mounted in the side of a tube $1\frac{1}{2}$ in. in diameter. The hole in the bottom of the funnel was $\frac{1}{4}$ in. in diameter and was within $\frac{1}{32}$ in. of the bottom of the inside of the tube. An air pipe with regulating valve was arranged as shown so that, as the dust ran out of the funnel, it was blown out in a fog. The rate of feeding could thus be controlled for, when the air was shut off entirely, the feeding stopped on account of the funnel opening being so close to the inside surface of the surrounding tube.

One of the difficult problems in connection with this test was the discovery of a dust of sufficient fineness to give the cleaners a good test and also one that could be duplicated for future tests. The search included visits to drug stores, where various finely powdered salts were examined. In the course of the search, parting compound, such as is used by molders in foundries, was examined and found to be very fine. The trade name for the compound is Patent Parting Compound and it is manufactured by the Peterson Core Oil & Mfg. Co., Chicago. It comes in barrel lots, and tests made with portions from different barrels showed homogeneity so far as the requirements for these tests were concerned. The dust is creamy yellow in color. It all passes readily through a 200-mesh sieve.

PROCEDURE

In making a run, the complete apparatus was set-up as shown in Fig. 3, except for the dust in the feeder. The air jet was opened and adjusted until the manometer gave a correct velocity reading. It was then allowed to run for $\frac{1}{2}$ hr., after which the felt was removed and weighed on scales sensitive to 0.1 gram. The felt was

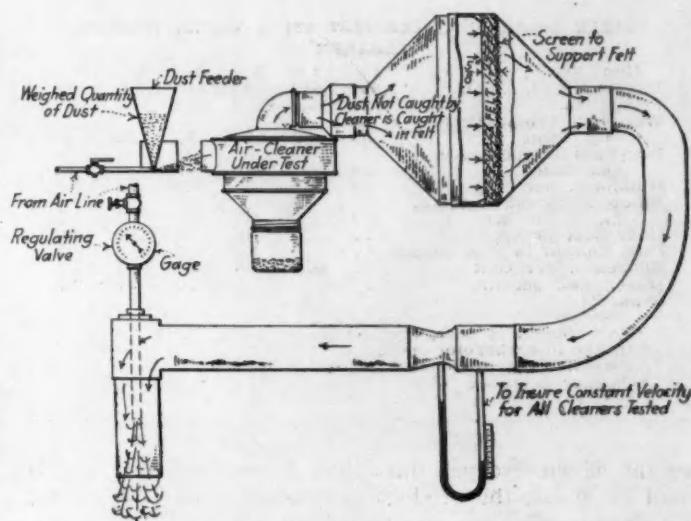


FIG. 3—ARRANGEMENT OF TEST APPARATUS FINALLY USED
In This Method the Air Enters the Cleaner under Test and the Dust is Blown In by the Dust Feeder as a Fog. From the Cleaner the Air Passes through the Layer of $\frac{5}{8}$ -in. Felt in the Double Funnel. The Suction is Caused by an Air Jet with Practically the Same Results as if an Engine Had Been Employed

then replaced and after a 15-min. run, weighed again. If it showed an increase over the previous weighing, it was again replaced and the apparatus operated for another 15-min. period. This process was continued until the weight became constant. This was done to allow the felt to become adjusted to the moisture content of the entering air. In water cleaners this caused a very appreciable increase in weight due to the humidifying effect of the cleaner itself.

After conditions became stabilized, 50 grams of the dust was placed in the feeder and fed at the rate of 50 grams in 30 min. The felt was then carefully removed and weighed. Any increase in weight was attributed directly to dust that had escaped the cleaner. The felt was then thoroughly cleaned and two more check-runs were made on the same cleaner. The net

Cleaner No.	Percentage Entering Engine						Efficiency, percent
	0	2	4	6	8	10	
1							87.8
2							89.4
3							90.0
4							90.6
5							93.0
6							93.5
7							96.0
8							98.0
9							97.4
10							98.5
11							98.7

FIG. 4—RESULTS OF THE EFFICIENCY TESTS ON 11 DIFFERENT CLEANERS

The Results Shown Are the Results of Three Runs on Each Cleaner. The Results Obtained with Cleaner No. 8 of the Water-Washer Type and No. 9 of the Dry Centrifugal Type Are Presented in Tables 1 and 2

TABLE 1—FINAL CHECK-TEST ON A WATER WASHER CLEANER^a

Run No.	1	2	3	4	5	6
Engine Speed, r.p.m.	1,000	1,000	1,000	1,000	1,000	1,000
Power, hp.	45.6	45.3	45.3	45.3	45.3	45.3
Wet-Bulb Temperature, deg. fahr.	56	59	60	61	62	60
Dry-Bulb Temperature, deg. fahr.	70	74	76	75	77	74
Humidity, per cent	40	39	38	44	42	43
Intake-Manifold Vacuum, in. of mercury	2.2	2.2	2.7	2.7	2.7	2.7
Dust Fed, grams	..	..	50	50	50	50
Dust Caught in Felt, grams	..	..	1.1	1.0	0.9	1.2
Efficiency, per cent	..	..	97.8	98.0	98.2	97.6
Water, gal. per hr.	..	..	..	..	..	0.1
Remarks	..	..	..	..	..	..

^a This cleaner is designated as No. 8 in Fig. 4.^b Intake to carburetor open.^c Flexible tube to cleaner attached.^d Cleaner attached.

weight of the escaped dust thus determined was multiplied by 2 and the product subtracted from 100, giving the cleaner efficiency in percentage.

ENGINE USED FOR CHECK RUN

After having determined the cleaner efficiency by the foregoing method, the same apparatus was set-up, using an engine and pulling a load on a Sprague cradle-dynamometer. The cleaners that showed-up the best in the previous test were then re-tested. It was found that the cleaning efficiency varied not more than 0.5 per cent in any case, in this run, from that obtained when using the air jet for suction. These cleaners were then attached to the engine carburetor directly and observations were made on each as to its effect on the power of the engine.

RESULTS

Fig. 4 shows graphically the results obtained in tests of 11 different cleaners. The names of the cleaners and their manufacturers are not mentioned, for obvious reasons. Tables 1 and 2 are given as typical of the results obtained on the final check-run. Corresponding readings were taken with and without the cleaner attached.

The results shown in Table 1 were obtained while using a cleaner of the water type. Readings were also taken of the water consumption. This is considered important from the standpoint of the amount of attention required from the operator. This particular cleaner consumed water, at full load, at the rate of 1 gal. per 10-hr. day, with the atmospheric relative humidity at 42 per cent. The cleaner held only 0.8 gal. of water and therefore would not last a full working-day. This is cleaner No. 8 on the graph in Fig. 4.

Table 2 gives the data obtained when using a cleaner of the dry centrifugal type. This is cleaner No. 9 in Fig. 4. In both cases the very close check on the cleaner efficiency will be noted.

I realize that these tests might be conducted with more elaborate apparatus. The feeder might be arranged

in an enclosed chamber composed of felt or eiderdown cloths or similar filtering media so that only filtered air would enter the cleaner. However, it is believed that the error introduced by using the air from an open room is so slight as to be negligible. Running the apparatus until the weight of the felt became constant proved this error to be immeasurable on scales sensitive to 0.1 gram, which means 0.2 per cent. The felt might be dried before and after each run but, for the same reason, I do not believe this is necessary. The time and expense involved in carrying out these refinements are not warranted in tests conducted by a manufacturer in his own laboratory for his own benefit. If the time of feeding were extended over a period of, say, 6 or 8 hr., it might be found necessary to be more careful as regards the room air, but I found that so long as the cleaner is not overloaded, that is, so long as the dust is not fed in slugs but rather in the form of a dusty atmosphere, the efficiency varies but slightly or not at all with different rates of feeding for any type of cleaner. From 15 to 30 min. is enough time to consume in feeding 50 grams and, during such a period, the amount of dust absorbed from the room atmosphere has been found to be so small as to be negligible; also, the atmospheric humidity will have varied so little during this short period that it will not have affected appreciably the weight of the felt cleaner.

ATTENTION BY OPERATOR

In making the final choice of a suitable cleaner, one might not necessarily select the one showing the highest cleaning efficiency. The second essential of a good cleaner was stated to be that it required the minimum of attention from the operator. It has been my experience, in close observation of this feature, that operators, as a rule, do not exercise the necessary care in connection with this apparatus. In one particular case a tractor was equipped with a cleaner of the water type in which a float arrangement automatically choked the carburetor inlet and thereby stopped the engine when the water reached a certain low level. Consequently, in such event the operator had to replenish the water before he could continue working. One day it was discovered that the float was held up by a wedge and that there was no water in the cleaner. Upon being questioned, the operator stated that he could not be bothered with feeding water to that cleaner all the time; that it was a nuisance.

In line with the general trend of recognizing this feature of automatic operation in the design of automotive apparatus, the air-cleaner designer must give thought and study to this side of the question as well as to that of efficiency. A storage-battery ordinarily requires that water be added to it once a week, but no really serious damage results if a week be missed. The user has learned to recognize this and his battery is seldom neglected. An air-cleaner positively should not require attention oftener than once a day under the most severe dust conditions of tractor operation. If this can be extended to once a week, once a month or indefinitely, so much the better. One manufacturer equips his tractors, ordinarily, with a dry centrifugal cleaner that ejects the dust as fast as it is separated. This, in general, requires no attention from the operator. It has no moving parts to wear-out. The efficiency of this cleaner is 97 per cent. Another cleaner of the filter type has an efficiency of 98.5 per cent, but, under extremely dusty conditions, it will become so filled with dust as to cause a serious choke on the carburetor inlet before the end of a working day. A full half-hour is required to wash this cleaner out with gasoline or kerosene and re-

TABLE 2—FINAL CHECK-TEST ON A DRY CENTRIFUGAL CLEANER^a

Run No.	1	2	3	4	5	6
Engine Speed, r.p.m.	1,000	1,000	1,000	1,000	1,000	1,000
Power, hp.	42	40	40	40	40	40
Intake-Manifold Vacuum, in. of mercury	2.5	3.5	3.5	3.5	3.5	3.5
Dust Fed, grams	..	50	50	50	50	50
Dust Caught in Felt, grams	..	2.0	1.4	1.3	1.4	1.4
Efficiency, per cent	..	96.0	97.2	97.6	97.2	97.2
Remarks	..	..	..	..	..	..

^a This cleaner is designated as No. 9 in Fig. 4.^b Cleaner not attached.^c Cleaner attached.

oil the filtering medium. However, the filter is sometimes furnished as extra equipment for bad conditions, where the 97-per cent efficiency of the centrifugal cleaner is not considered sufficient. In these cases both cleaners are used in series. The centrifugal cleaner removes the first 97 per cent and, in this way, the filter is relieved to such an extent that it can easily go a week without attention. The filter is very efficient in absorbing the very fine dust that escapes the centrifugal cleaner. The combined efficiency of the two is about 99.9 per cent.

METHOD OF ATTACHMENT

The method of attachment is also very important in that it makes for the success or failure of a cleaner. I have observed installations in which one's hand could be placed over the cleaner inlet while the engine was pulling full load and the mixture was only slightly enriched, and the load was still 90 per cent of maximum. A poor grade of flexible tubing was used to connect the cleaner to a stove. The same grade of tubing was used from the stove to the carbureter. All connections of the tubing were sloppy. The stove was loosely fitted to the exhaust pipe so that a crack aggregating 15 in. of length and roughly 1/16 in. in width was evident. A cleaner installed in this manner is of no value whatever. A grade of tubing should be used which is positively air-tight. Likewise, the end connections should be tight. A practice that has proved very good is the use of standard flange connections throughout. These flanges are soldered to the tubing and copper-asbestos gaskets are inserted at the connections to the cleaner and the carbureter. If a carbureter that has two air-intakes is used, both of these should be connected to the air-cleaner.

Fig 5 shows an installation in which the tubing connection from the cleaner to the carbureter is soldered to the carbureter inlet and to the air-cleaner outlet. A gasket is used under the flange connection on top of the cleaner. If a stove is used, installed in such a way that the air is clarified before going through the stove, the latter should be air-tight. The leakage of air through loose joints defeats the purpose of the air-cleaner.

POWER LOSSES IN OPERATION

The third essential, that of minimum power-loss, must, in a measure, be balanced against the other two essentials. In a particular case, it may be wise to accept a small loss in power, provided the cleaner is efficient and requires little or no attention to assure its continuous functioning. From Table 2 it will be noted that the intake-manifold vacuum increases from 2.5 to 3.5 in. of mercury, with the addition of the cleaner, and that the power decreases from 42 to 40 hp. Of course, the mix-

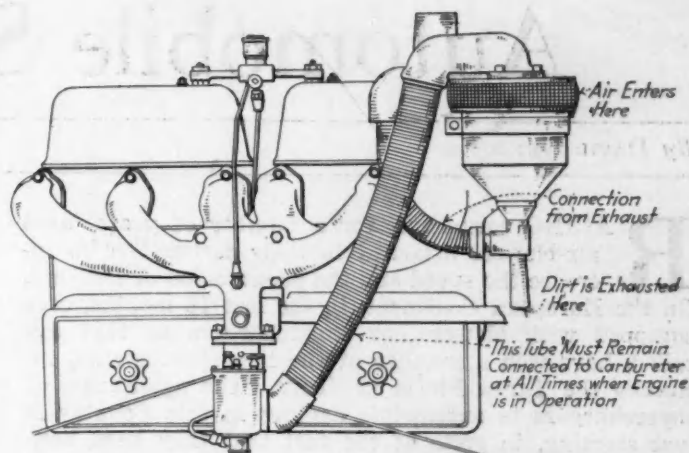


FIG. 5—AN EXAMPLE OF A SATISFACTORY AIR-CLEANER INSTALLATION
The Flexible Tube Is Soldered to the Carbureter and the Cleaner with a Gasket Is Placed under the Flange Connection on the Top of the Cleaner. This Installation Combines Good Cleaning Efficiency with Continuously Automatic Operation and Small Bulk. It Causes a Loss of 2 Hp. Which Is Accepted as a Part of the Price Paid for Its Other Good Features

ture must be readjusted for best results when the cleaner is attached; but, in this particular case, the efficiency of the cleaner is fairly good and the dust is automatically ejected from the cleaner as fast as it is separated, thus requiring no attention from the operator.

In Table 1, which represents the test of a water cleaner, a slight power-loss is noted as a result of attaching the tubing to the carbureter. This emphasizes the importance of having all such tubing amply large. However, when the cleaner itself was attached, although the vacuum increased from 2.2 to 2.7 in. of mercury, no decrease in power was noted, because of the increased combustion efficiency due to the moisture from the cleaner. This cleaner also showed an efficiency of 98 per cent but, since under heavy load the water would not last throughout a working day without replenishment, this cleaner was not desirable. The bulk of the cleaner is also a point worthy of consideration. A manufacturer must be able to incorporate the cleaner into the design in such a way that it will not be an eyesore, as well as make it accessible for attention, if necessary.

The Agricultural Engineering Division of the University of California has conducted some very thorough tests of air-cleaners under the supervision of its research specialist, Prof. Arthur H. Hoffman. He has given very careful study to the air-cleaner problem and has devised very elaborate and efficient methods of test. Bulletins may be secured by writing to Professor Hoffman at University Farm, Davis, Cal.

LIQUIDATION OF SURPLUS BRITISH WAR MATERIAL

IT is reported that the British Disposal and Liquidation Commission in charge of the disposal of surplus war supplies and equipment brought its activities to a close on March 31, 1924, after 5 years during which more than 3,000,000 transactions involved sales that amounted to more than \$3,000,000,000. In addition to the sale of surplus stocks, nearly 1,000,000 tons of ammunition were broken down, 170,000 tons of poison gas and explosives were burned or sunk at sea, and 22,000 tons of unsalable cardite were burned in Government magazines.

The sales were productive of a profit. Receipts of £335,000,000 (approximately \$1,500,000,000) from the sale of raw

materials, including wool, flax, hemp, jute and leather, gave a profit of nearly £78,000,000 (about \$345,000,000) which was divided between the home Government and certain Dominions. Claims to the number of 750,000 were adjusted or settled.

The most favorable feature in the situation is that one more exceptional characteristic of day-by-day business has been removed, so that the operation of the business cycle is to that degree more nearly normal. This surplus supply of textiles, foodstuffs, timber and the like is exhausted and the demand must again be met from the ordinary source of supplies.—*Economic World*.

Automobile Superchargers

By DAVID GREGG¹

Illustrated with DRAWING

RACING cars have, for a number of years, used air-blowers attached to their carbureters to increase the speed and the acceleration of the cars. On the European Continent, in the last 18 months, cars equipped with blowers, or superchargers as they are called, have won a number of the important events, including the Targa Floria in Sicily. The application of superchargers to automobile engines in this Country is just starting, in spite of the fact that they have been used here on aircraft for some time and have been responsible for a majority of the world's altitude records. Already, promising results have been secured on the few cars in this Country that have been equipped with superchargers. A Duesenberg car equipped with a supercharger of my own design won the recent 500-mile race at Indianapolis, making a new record for the course.

Two obvious lines of development exist in the application of superchargers to automobile engines: First, to supercharge racing engines of limited piston displacement so as to increase the power and the speed range; second, to design an engine that has a supercharged induction system incorporated in it.

Let us consider the first development. Racing rules have gradually reduced the piston displacement until the present 122-cu. in. engine was reached. To maintain speed and power, builders have constantly increased the speed and the compression-ratio of the engines, which has, of course, increased the power output per unit displacement. Compression-ratios of 7 to 1 and speeds of 5000 r.p.m. are now in use. Fuel doped with anti-knock, or benzol mixture, permits higher compression-pressures.

In spite of the fact that the power has increased with the increased compression-ratios, the intake charge is limited to the piston displacement multiplied by the volumetric efficiency of the engine. For example, the 122-cu. in. four-stroke cycle engine sucks in 61 cu. in. multiplied by a volumetric efficiency of perhaps 90 per cent, or some 55 cu. in. of intake charge at each revolution. With the supercharger, the weight of intake charge can be increased by increasing the intake pressure. This will, of course, increase the final pressure, provided the compression-ratio is unchanged.

If the final pressure is already as high as is desired, an increase in power can be obtained by lowering the compression-ratio and supercharging enough to give the same final pressure as in the high-compression engine. For example, take a single cylinder having a displacement of 100 cu. in. and a compression-ratio of 8 to 1. With the piston on top dead-center, the combustion area would equal $C_h = 100/(8-1)$ or 14.3 cu. in. Now assume the same cylinder with a 4 to 1 compression-ratio and determine the size of supercharger necessary to maintain the same final pressure as in the 8 to 1 engine. The combustion area of the 4 to 1 engine equals $C_h = 100/(4-1)$ or 33.3 cu. in.

DETERMINATION OF SUPERCHARGER CAPACITY

In determining the supercharger capacity, the following notations are used:

¹ S.M.S.A.E.—Research engineer on superchargers, engineering division of the Air Service, McCook Field, Dayton, Ohio.

P_1 = intake pressure of high-compression engine, or about 14.7 lb. per sq. in.

P_2 = final pressure

r = compression (pressure) ratio of supercharger

R_h = compression (volume) ratio of high-compression, 8 to 1, engine

R_l = compression (volume) ratio of low-compression, 4 to 1, engine

rP_1 = intake pressure of supercharged low-compression engine

$P_2 = P_1 \times (V_1/V_2)^n$ and $V_1/V_2 = R$

Therefore, for the high-compression engine

$$P_2 = P_1 (R_h)^n \quad (1)$$

And, for the low-compression engine, supercharged,

$$P_2 = rP_1 (R_l)^n \quad (2)$$

As the final pressures are the same, the two equations are equal; hence,

$$rP_1 (R_l)^n = P_1 (R_h)^n \quad (3)$$

$$r = [R_h/(R_l)^n] \text{ or } 2.66 \quad (4)$$

Thus, by means of a supercharger having a 2.66 to 1 compression (pressure) ratio, we can supercharge the 4 to 1 compression engine to the same final pressure as the 8 to 1 compression engine. The final temperatures are also sensibly the same. We have, moreover, increased the weight of the intake charge by the ratios of the two combustion volumes, or about 2.35 times. The power, however, does not increase in the same ratio as the weight of fuel charge.

ENGINE POWER-OUTPUT COMPARISONS

E. T. Jones, chief of the powerplant section, McCook Field, has devised a simple method of comparing the power outputs of engines of different compression-ratios. To estimate the increase in power of a supercharged low-compression engine over that of an unsupercharged high-compression engine, the standard indicator-card is compared with that of the low-compression engine. To do this most conveniently, it is assumed that the cylinder dimensions of the low-compression engine are reduced so that the volume of the clearance space in the low-compression engine is equal to that in the high-compression engine. This diagram is shown in Fig. 1. It should be noted that the reduced indicator-diagram is not used directly in computing power output, but merely in estimating the mean effective pressure. Under these conditions the compression, explosion and expansion lines of the two diagrams are identical, the only difference being in the fact that the piston displacement in the low-compression engine will be less than that of the high-compression engine and the shape of the toe of the card will be altered. This is shown in Fig. 1. To construct this diagram, it is necessary to compute the relative volumes of the compression spaces of the high and the low-compression engines. This can be done as follows: If the clearance volume of the low-compression engines be indicated by C_l and that of the high-compression engine by C_h , then

$$C_l = R_l/(PD_l + C_l) \quad (5)$$

and

$$C_h = R_h/(FD_h + C_h) \quad (6)$$

Inasmuch as the displacements are equal in both en-

gines, the clearance volumes of the actual engines will have the ratio

$$C_l/C_h = (R_h - 1)/(R_l - 1) = (8 - 1)/(4 - 1) = 2.33$$

In plotting the diagram on the basis of equal clearance volumes, the piston displacement of the low-compression engine, PD_l , will be equal to the piston displacement of the high-compression engine, PD_h , divided by 2.33, that is,

$$PD_l = PD_h/2.33 \text{ or } 0.429 PD_h \quad (7)$$

The mean effective pressure of the standard engine is about 140 lb. per sq. in. and is equal to the area of the indicator-card divided by its length. If we call the area of the standard card A , the area of the low-compression card will be equal to A less the area of the portion cut-off at the toe, which we will call A_1 . The mean-effective pressure of the low-compression card will then be equal to $(A - A_1)/PD_l$.

The area of the toe of the card is equal to the piston displacement of the high-compression card minus the piston displacement of the low-compression card multiplied by the average pressure of this portion of the card. Without actual measurement, this pressure can safely be estimated at 60 lb. per sq. in. We now write the equation for the mean effective pressure of the low-compression card as follows:

$$MEP_l = PD_h \times MEP_h - 60 \times (PD_h - PD_l) \quad (8)$$

Equation (8) can be reduced to

$$MEP_l = PD_h/2.33 \times MEP_h - [60 \times (PD_h/2.33)] + 60 \quad (9)$$

Substituting the numerical values for the 8 to 1 and the 4 to 1 compression engines, we have

$$MEP = (2.33 \times 140) - (2.33 \times 60) + 60 = 247 \text{ lb. per sq. in.} \quad (10)$$

FUEL CONSUMPTION

Since, in the actual engines, the piston displacements are equal, the power developed will be proportional to the mean effective pressure, if the mechanical efficiency is assumed to be the same in each case. Thus, the power of the low-compression engine is equal to the power developed by the high-compression engine multiplied by the ratio of 247 to 140; that is, the low-compression engine gains an increase in power of 76 per cent over that of the high-compression engine. This is secured at the expense of a 133-per cent increase in the fuel consumption.

Part of this increase in fuel consumption is due to the increase in power; so, the increase in specific fuel-consumption is much lower. Consider an engine of 100 hp. with a specific fuel-consumption of 0.5; that is, it uses 50 lb. of fuel per hr. When the power is increased by means of the supercharger to 176 hp., the fuel-consumption increases to 116.5 lb. per hr. This, divided by the horsepower output, gives a specific fuel-consumption of 0.663 lb. per hp-hr., or an increase of 32.8 per cent.

POWER DEVELOPED

The example cited is, of course, an extreme case and, in actual practice, a supercharger with a lower pressure-ratio probably would be used. In fact, an appreciable power-increase can be secured by supplying a supercharger just large enough to overcome the decrease in volumetric efficiency of the engine as the engine speed increases. In other words, the supercharger, by increasing the intake pressure slightly, would fill the cylinders with a greater weight of charge at higher engine speed

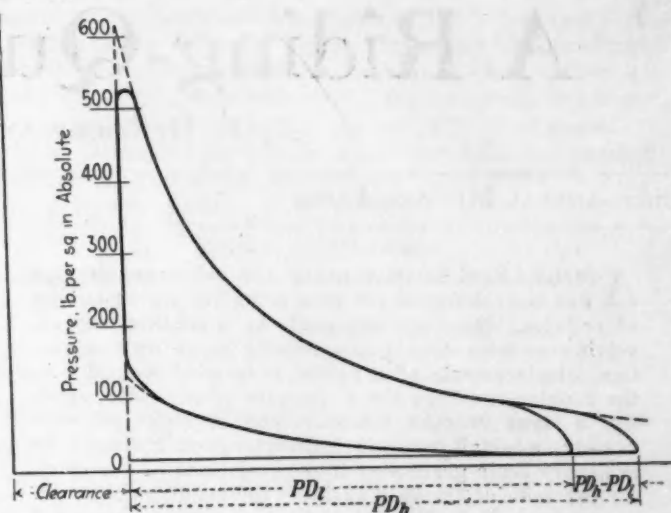


FIG. 1—A COMPARISON OF THE HIGH AND LOW-COMPRESSION CYCLES ON THE BASIS OF EQUAL COMPRESSION-VOLUME AND COMPRESSION PRESSURE

This Diagram Provides an Easy Means of Estimating the Increase in Power of a Supercharged Low-Compression Engine Over an Unsupercharged High-Compression Engine. The Cylinder Dimensions of the Low-Compression Engine Are Reduced So That the Volume of the Clearance Space Is Equal to That in the High-Compression Engine. This Reduced Indicator-Diagram Is Not Used Directly in Computing the Power Output but Merely in Estimating the Mean-Effective Pressure. Under These Conditions the Compression, Explosion and Expansion Lines of the Two Diagrams Are Identical, the Only Difference Being That the Piston Displacement in the Low-Compression Engine Will Be Less than That of the High-Compression Engine and the Shape of the Toe of the Card Will Be Altered

than is possible with the unsupercharged engine in which the volumetric efficiency decreases with the increase in gas velocities through the intake-manifolds and valves. Actual experiments on a 122-cu. in. racing engine with a supercharger of 1.2 to 1 compression-ratio have shown an increase in the engine speed from 4200 to 5600 r.p.m., giving a power increase of better than 40 per cent.

The majority of superchargers used up to the present time supply the carburetor with air at higher than atmospheric pressure and necessitate a means of supplying fuel to the carburetors at a constant pressure slightly above that of the supercharger. In the supercharged induction system that I designed for automobile engines and that was first used on the Duesenberg cars, all the fuel and air mixture passes through the supercharger, where the rapidly revolving fan and the heat of compression aid in vaporizing the fuel so that a practically dry gas is delivered to the intakes. As a result, the difficulties of mixture distribution to a multi-cylinder engine are practically eliminated, and a smooth-running engine is obtained. As the carburetor is located at the supercharger inlet, the throttle also controls the amount of supercharging; so, with one control, all speeds from idling to full-open are obtained, the design of the supercharger determining the maximum final-pressure at which the mixture is delivered to the intake-valves. The power required to drive the supercharger amounts to 2 or 3 per cent of the total power of the engine; this small amount has been neglected in the foregoing discussion.

While superchargers for automobile engines are only in the first stages of development, the results so far obtained certainly justify their use on racing cars, and it is my belief that the next year or so will witness their application to the better grades of passenger car.

A Riding-Quality Indicator

By E. H. LOCKWOOD¹ AND L. B. KIMBALL²

SEMI-ANNUAL MEETING PAPER

Illustrated with DRAWING AND PHOTOGRAPH

A PORTABLE instrument of the seismograph type has been designed for measuring the riding-quality of vehicles. Readings are made by a continuously revolving counter that automatically sums up the vertical displacements of a partly suspended weight. As the counter readings are a measure of the riding-quality, a large reading indicates poor riding and, conversely, a small reading indicates good riding. An arbitrary scale graduated into revolutions of the counter per mile of travel translates the readings into riding-quality; a reading of 10 indicates "very smooth," 20, "good," etc. The instruments have been calibrated in a special testing-machine in which the readings can be observed under an harmonic motion of fixed period and amplitude.

Comparison of the riding-quality of balloon tires and of cord tires, made on three different automobiles run over a variety of roads, shows results that are very favorable to balloon tires. Data on the effect of shock-absorbers and of car speed on riding-quality are now being obtained. Detailed records of the riding-quality of an airplane, as measured by the integrating instrument, show the airplane to be slightly better than the best automobile.

THE final verdict of riding-quality must rest with the driver or the passengers of the vehicle. Any measuring-instrument, therefore, must give readings that can be interpreted in accordance with the sensations of the passengers. This agreement may be of an approximate order only, but it has the advantage of transferring the findings from a psychological to a mechanical basis, from which definite conclusions can be drawn.

Discomfort in riding comes in part from minor causes, such as squeaks, rattles and engine vibrations, but the most objectionable single item is the vertical acceleration produced by the body springs. The present instrument was designed to measure vertical acceleration only. It has been called a seismograph because it employs a suspended weight from which the instrument readings are made. It belongs to the integrating type, wherein the displacements of the suspended weight are automatically summed up as fast as they occur. The observer has only to read the recording dial at intervals to obtain a measure of the total displacement, which, in turn, is translated into riding-quality on an arbitrary scale.

CONSTRUCTION OF INSTRUMENT

Before discussing the uses of the instrument it will be well to examine its construction. This will be made clear by Fig. 1 and reference to the following symbols:

- a* is a weight suspended by a flexible cord passing over a pulley *e* and constrained by anti-friction guides to move vertically without side-sway
- b* is a tension spring fastened to one end of the flexible cord
- c* is a screw adjustment for varying the initial tension of the spring

d is a table underneath the block *a* and normally supporting a small part of its weight. The table is held normally against stops by compression springs of sufficient tension to keep the table fixed for small rebounds of the weight, but yielding somewhat for large rebounds. The object of the springy table is to magnify the instrument readings on rough roads

e is a pulley that turns with the flexible cord whenever the weight *a* rises from the table *d*

f is a friction ratchet, driving in one direction from the motion of the pulley *e*

g is a holding pawl that keeps the ratchet *f* from turning backward

h is a driven shaft, receiving its motion from the friction ratchet *f*, and moving intermittently, depending on the frequency and amplitude of the flexible cord movements

i is a continuously rotating counter that records revolutions of the shaft *h* and thus sums up the vertical displacements of the weight

The drawing shown in Fig. 1 is partly diagrammatic. The actual appearance of the instrument is shown photographically in Fig. 2. The general dimensions and instrumental constants are

Height Overall, in.	16
Floor-Space Occupied, in.	6 x 10
Actual Weight of <i>a</i> , lb.	2
Proportion of Unsupported Weight, per cent	10
Initial Deflection of Spring, in.	6.75
Vertical Displacement Equivalent to 1 Revolution of the Counter, in.	2.37

A calibrating machine was devised to check the constancy of the instrument readings. It consists of a guided crosshead that transmits harmonic motion of known period and amplitude to the integrating instrument. Two standard calibrations were used: No. 1 had 134 periods per min. and a 0.62-in. stroke and registered 0.80 r.p.m.; No. 2 had 134 periods per min. and a 0.90-in. stroke and registered 6.00 r.p.m.

The vertical acceleration of the crosshead was sufficient to lift the suspended weight from the supporting table of the instrument. The actual rise from the table in calibration No. 1 was only 0.014 in. for each cycle of the crosshead.

USE AND READING OF INSTRUMENT

In actual use the suspended weight is observed to rise by small rebounds from the table for ordinary riding, with occasional jumps of 1 in. or more for rough spots. All these displacements are automatically summed up by the ratchet mechanism and counter on top of the instrument, where the total can be read at any time.

An analysis has been made of the height to which the weight will rise for a given acceleration of the instrument, with results that have been partly confirmed by experiment. The mathematical reasoning is deemed to have but little practical application, since it cannot be translated properly into riding-quality. The instrument will give a definite reading for any kind of shock or acceleration, provided that it is great enough to lift the weight from the supporting table. For example, the in-

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A RIDING-QUALITY INDICATOR

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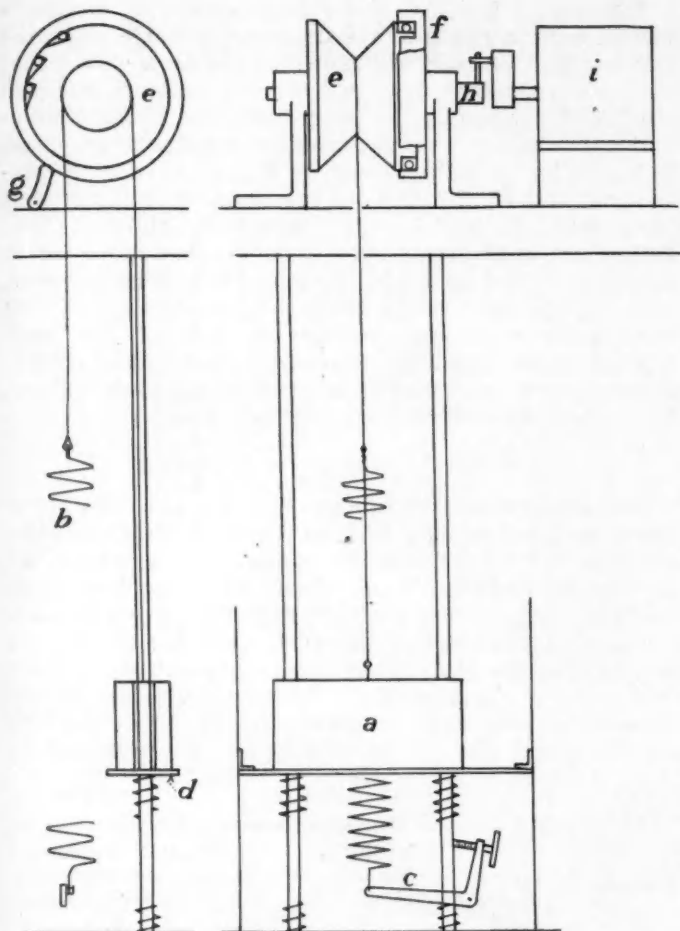


FIG. 1—INTEGRATING SEISMOGRAPH FOR MEASURING THE RIDING QUALITY OF MOTOR VEHICLES

This Drawing Is Partly Diagrammatic and the Construction Is Made Clear by Referring to the Following Description of the Various Parts. The Weight *a* Is Suspended by a Flexible Cord Passing Over a Pulley, *e*, and Having the Tension Spring *b* Attached to One End. The Initial Tension of This Spring Is Varied by the Screw Adjustment *c*. The Table *d*, Located Underneath the Weight *a*, Normally Supports a Small Part of Its Weight. The Friction Ratchet *f* Drives in One Direction from the Motion of the Pulley *e* Whenever the Weight *a* Rises from the Table *d* and Is Prevented from Turning Backward by the Holding Pawl *g*. The Driving Shaft *h* Receives Its Motion from the Friction Ratchet and Moves Intermittently Depending upon the Frequency and Amplitude of the Flexible Cord Movements. The Revolutions of the Shaft *h* Are Recorded by the Continuously Rotating Counter *i*, Thus Summing Up the Vertical Displacement of the Weight *a* That Is Constrained To Move Vertically without Side-Sway by Anti-Friction Guides. The Table *d* Is Normally Held against Stops by Compression Springs of Sufficient Tension To Keep the Table Fixed for Small Rebounds of the Weight, but Yielding Somewhat for Large Rebounds. The Object of the Springy Table Is To Magnify the Instrument Reading on Rough Roads

strument on the car floor will record engine vibration, in which case the counter will advance steadily without any visible motion of the suspended weight. While the actual displacement of the car body by engine vibration is very minute, the acceleration produced by each vibration may be relatively large. In this instrument, the suspended weight would have a downward acceleration of 0.1 *g* or 3.2 ft. per sec. per sec.; hence an opposing engine acceleration of greater magnitude must exist to lift the weight. The position of the measuring instrument in the car is a matter of importance. The location chosen for it in these tests was the car floor, in a position convenient for an observer on the rear seat. The method of using the instrument was to take a reading at the beginning and another at the end of a given course, as indicated by markers on the side of the road. The dif-

ference in the readings is an index of the riding-comfort, based on some arbitrary scale connecting the readings with riding-quality. The markers have been spaced at 1-mile or ½-mile intervals, but the instrument readings have been reduced to revolutions per mile in all cases.

A tentative riding-quality scale for this instrument has been adopted from observations made when running over different roads.

RIDING QUALITY SCALE

Very Smooth	Below 10 Revolutions per Mile
Good	10 to 25 Revolutions per Mile
Fair	25 to 35 Revolutions per Mile
Passable	35 to 50 Revolutions per Mile
Hard Riding	Over 50 Revolutions per Mile

Some typical records of this instrument made on different vehicles have been collected in Table 1.

TABLE 1—TYPICAL RECORDS OF THE INTEGRATING SEISMOGRAPH IN REVOLUTIONS PER MILE

Railroad Coach	0
DH-4 Airplane, with Liberty Engine	2.0
Automobile Equipped with Balloon Tires, on Very Smooth Concrete	2.0 to 8.0
Automobile Equipped with Cord Tires, on Very Smooth Concrete	15.0 to 25.0
Automobile on Average Macadam, at 20 M.P.H.	35.0 to 65.0
Automobile on Very Rough Dirt Road, at 15 M.P.H.	200.0
Double-Truck Trolley Car	Trace

RIDING-QUALITY OF BALLOON TIRES

Comparative tests have been made on three different automobiles, two sets of wheels being available that allowed the interchangeable use of standard cord tires or of balloon tires.* All the cars, data for which are given in Table 2, were fitted with shock-absorbers, and were representative automobiles of their respective classes.

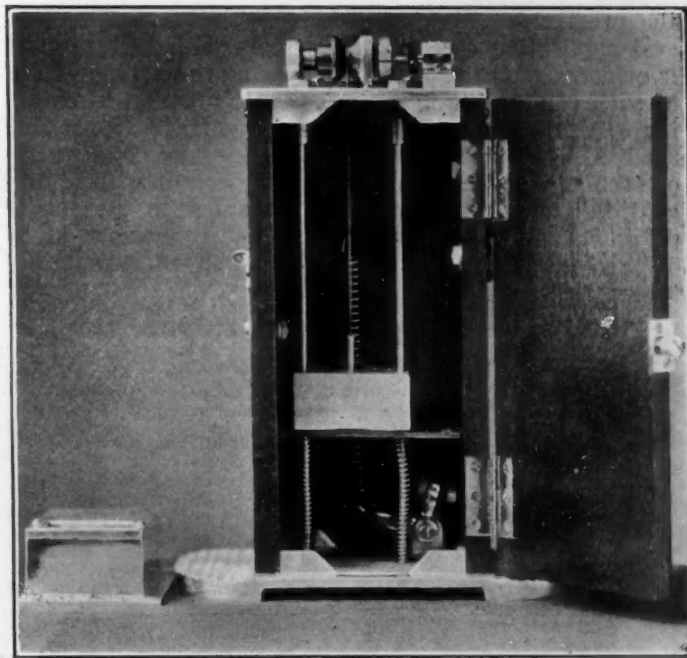


FIG. 2—PHOTOGRAPH OF THE INSTRUMENT

The General Dimensions and Instrumental Constants Are	
Overall Height, in.	16
Floor Space Occupied, in.	6 x 10
Actual Weight of <i>a</i> , lb.	2
Proportion of Unsupported Weight, per cent	10
Initial Deflection of Spring, in.	6 ¼
Vertical Displacement Equivalent to 1 Revolution of Counter, in.	2.37

*The entire equipment for these tests was loaned by the Fisk Rubber Co., of Chicopee Falls, Mass.

TABLE 2—DATA ON CARS USED IN RIDING-QUALITY TESTS

Car	A	B	C
Weight of Car, lb.	4,410	2,660	2,240
Wheelbase, in.	132.0	114.5	100.0
Cord Tires, in.	33 x 5.00	29 x 4.50	30 x 3.50
Balloon Tires, in.	34 x 7.30	32 x 6.20	30 x 5.25

The figures in Table 3 indicate the value of balloon tires for improving riding-quality on city pavements at moderate speeds.

Car B was the hardest-riding of the cars. Its record of 67 on an average macadam road was very poor according to the riding-quality scale. By the use of balloon tires the record was changed to 11, or the very smooth class.

Car C was the easiest-riding with cord tires on all the roads, and even here the balloon tires showed considerable improvement.

The concrete road was a new pavement of most approved construction, but the cord-tire equipment showed considerable vibration in passing over it, whereas with balloon tires the vibration was reduced to a negligible amount.

It is probable that the combination of roads and speeds used in these tests was favorable to balloon tires. Under other conditions, such as very rough roads at low speeds, the normal action of the springs may be accentuated by balloon tires in a disagreeable manner. The present type of instrument has been tried to a limited extent on a two-block dirt road of the roughest kind, where 10 m.p.h. was the upper limit of speed for most cars. Car B was driven over this course with the two equipments of cord and balloon tires. The integrating instrument showed a marked difference in favor of balloon tires, which perhaps was partly due to the effective shock-absorbing devices used. The conditions under which balloon tires become objectionable have not been discovered in the preliminary trials of the instrument.

Thus far the present type of instrument has not been applied to measuring the riding-quality as affected by the presence or absence of shock-absorbers. The general application of snubbing devices with balloon tires is evidence of their value in improving the riding-quality of such equipment. They are probably useful in checking excessive rebounds when crossing tracks, holes and the like, whereas on smooth roads they may be of no use or even slightly detrimental to riding-comfort. The integrating instrument seems well adapted to measuring differences in riding-comfort produced by various kinds of shock-absorber, and data on this subject may be obtained in the future.

TABLE 3—RIDING-QUALITY OF CORD VERSUS BALLOON TIRES⁴

Car	Type of Tire	Inflation-Pressure, Lb. per Sq. In.	Rough Wood Blocks, Speed		Smooth Concrete, Speed
			20 M.P.H.	30 M.P.H.	
A	Cord	50	154	35	25
A	Balloon	25	29	5	2
B	Cord	40	..	67	..
B	Balloon	20	52	11	..
C	Cord	45	57	19	14
C	Balloon	25	19	11	6

⁴ Figures in last three columns represent integrator readings in revolutions per mile.

Systematic tests of the riding-quality of a vehicle should cover a range of speeds from 10 m.p.h. up to the highest that the road will allow. It can be predicted that the riding-quality curve will not be uniform but will vary with the speed. In many cases the riding-discomfort curve will reach a maximum at some medium speed, being better at either lower or higher speeds. A preliminary test of this kind has been made with the present instrument, in which eight cars with different tire-equipment were driven over a smooth concrete road at speeds of 30 and 40 m.p.h. As might have been expected, each vehicle gave nearly the same readings at the two speeds. It was observed that the balloon tires gave slightly higher readings at a speed of 40 m.p.h., while the cord tires gave slightly lower readings at this speed, but in both cases the differences were small.

RIDING-QUALITY OF AN AIRPLANE

The integrating instrument was carried from New Haven to Boston and return on April 28, 1924, in DH-4 airplane No. 64,621, loaned by the United States Air Service, Mitchel Field, Long Island. Readings were taken by Lieut. F. L. Parks, graduate student, Yale University. Lieut. M. L. Elliott was the pilot. The log of the trip showed that the instrument began to count slowly as a result of the vibration of the Liberty engine before the airplane started and continued to register during the entire flight. The results of this test are presented in Table 4.

TABLE 4—AIRPLANE SEISMOGRAPH RECORDS⁴

Place	Net Revolutions of Counter	Net Time, Min.	Revolutions per Mile, Approximate
Aviation Field	0	0.0	..
Leaving Ground	14	2.3	..
Railroad Station at New Haven	48	8.0	4.0
New London	153	30.0	3.3
Providence	119	30.0	2.4
Boston, Struck Ground	123	28.0	2.4
Boston, at Rest	13	0.7	..
Total	470	99	Averg. 2.9

The trip, for which figures are given in Table 4, was made at an average altitude of 3000 ft. against a head wind of 15 m.p.h. The return trip was made with the wind, in 86 min. The seismograph reading on the return trip averages only 1.3 revolutions per mile, or less than one-half that on the eastward trip. The instrument readings indicate, apparently, that the riding-quality of the airplane is about on a par with that of the best automobile with balloon tires on the smoothest pavement. It is probable, however, that the integrating instrument registered considerable engine vibration and that, if this item were eliminated, the remainder due to airplane acceleration might be very small indeed.

Airplane accelerations have been measured accurately by official instruments devised for this purpose. The present comparison has been made to show that the riding-quality of an airplane appears to be slightly better than that of the smoothest-riding automobile.



A Possible Solution of the Crankcase-Oil Dilution Problem

By IVAN L. ANDERSON¹

Illustrated with PHOTOGRAPHS AND DIAGRAMS

CRANKCASE-OIL dilution is caused by gasoline, or other light petroleum products, getting into the oil. This causes the oil to have insufficient body to hold the bearing surfaces apart and the result is often a burned-out bearing. It is a well-known fact that crankcase-oil dilution increases progressively with a decreasing volatility of the fuel. It is evident, therefore, that crankcase-oil dilution is an obstacle that must be removed before fuel of a lower volatility can be used economically.

Dilution of the crankcase oil is primarily due to three causes:

- (1) The lubricating oil on the cylinder walls becoming diluted with fuel during the admission and compression strokes and leaking back into the crankcase
- (2) Over-lubrication keeping the explosion chambers wet, aiding condensation and draining back past the pistons into the crankcase
- (3) Cracking, or the decomposition of the lubricating oil that has come into contact with the under side of the piston-head or other heated surface

Any one of several methods may be applied in attacking the crankcase-oil dilution problem. Among them are the following:

- (1) Prevent any gas, or liquid, from escaping past the piston into the crankcase
- (2) Drain the oil from the crankcase, reclaim it and reuse it
- (3) Constantly reclaim the oil as the engine is running
- (4) Ventilate the crankcase thoroughly, thereby removing the light ends that dilute the oil

The first method may be aided by the use of a high grade of fuel that vaporizes completely; but we cannot resort to a higher grade of fuel because of the limited supply. Our aim is to be able to use a fuel of lower volatility. The escaping of the gas may also be prevented by a perfect-fitting piston and a leak-proof piston-ring. The condition of perfect fit is not to be found in present-day engines that have been used for any length of time. Where it has been approached, special leak-proof piston-rings have been used, the design otherwise complicated, and the first cost increased. It may be possible, however, to perfect the design so that much of the present leakage will be prevented.

The second method, that of draining the crankcase and reclaiming the oil, requires time and labor. It is greasy and disagreeable and necessitates a reclaiming apparatus. This reclaiming apparatus not only utilizes a filter but also consists of some form of still. The high cost of the reclaiming apparatus makes this method still more undesirable. Much has been said recently relative to installing stations for this purpose. Large filtering-stations are likely to be the only means that will utilize this method to any extent, as it is not practicable to reclaim small quantities of oil.

For the third method, constantly reclaiming the oil,

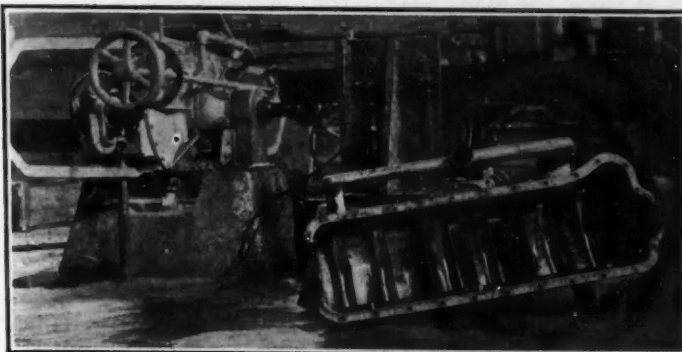


FIG. 1—THE INLET CONNECTION TO THE CRANKCASE
The Air Was Taken In through the Forked Duct and Entered the Crankcase at Both Ends Just above the Level of the Oil. This Duct Must Be Very Large and Free from Resistance, Having an Effective Area of Approximately Twice the Area of the Carbureter Air-Intake

several different devices have been used, in which a distilling apparatus has been installed on the car with more or less success so far as the actual reclaiming goes. They are not simple, however, and add to the complexity of the powerplant.

The fourth method, ventilating the crankcase, would of necessity operate continuously while the engine is running. It is easily accomplished and requires a very simple apparatus and almost negligible power for its operation.

METHOD OF REMOVING GASOLINE BY VENTILATION

After a careful consideration of the relative advantages and disadvantages of the methods listed above, the last one, that of removing the gasoline from the crankcase by ventilation, seemed to have the most merit, as it is simple and appears entirely feasible.

The means of doing this was the passing of a current of air through the crankcase in such a way that the entire crankcase would be scavenged. The current of air was produced by passing all the air that entered the

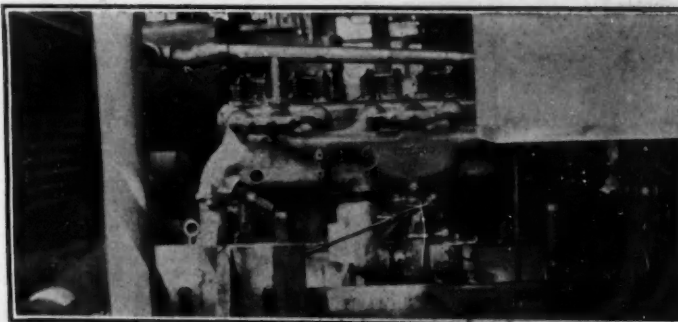


FIG. 2—ONE TYPE OF CONNECTION TRIED BETWEEN THE CRANKCASE AND THE CARBURETOR

The Air Was Taken into the Crankcase at the Right Side and Expelled at the Left To Have the Air Flow in the Opposite Direction to That in Which the Oil Is Splashed by the Connecting-Rod. This Arrangement Caused the Minimum Amount of Oil To Be Carried into the Carburetor in the Form of a Very Fine Spray

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carbureter through the crankcase first. This would not only ventilate the crankcase, but would keep the crankcase oil cooler and carry the waste vapor into the combustion-chamber.

Fig. 1 shows the inlet connection to the crankcase. The air was taken in through the forked duct and entered the crankcase at both ends just above the level of the oil in the oil-pan. This duct, it was found, must be very large and free from resistance, having an effective area about twice that of the air-intake on the carbureter. If it were not made very large, so as to create a minimum resistance to the flow of air, the volumetric efficiency would drop considerably. The long distance that the air must travel necessitates a minimum frictional resistance in all ducts. The air was taken out from the opposite side of the crankcase at a point just in front of the carbureter and as high as possible, but below the level of the air-intake of the carbureter.

Fig. 2 shows the location and one type of connection tried between the crankcase and the carbureter. The air was taken into the crankcase from the right-hand side and taken out at the left. This was done to have the current of air flow in a direction opposite to that in which the oil is splashed by the connecting-rods, so that the minimum amount of oil in the form of very fine spray would be carried into the carbureter.

The engine used in the experiments was a six-cylinder model E-45 Buick, equipped with a Marvel carbureter. The engine was in good condition at the beginning of the tests, having been completely overhauled and run just enough since to "break it in."

The cooling-water was supplied to the jackets at a temperature of 120 deg. fahr.

A 14-in. Herschel Spillman hydraulic brake, shown in Fig. 3, was used to supply the desired load.

DESCRIPTION OF APPARATUS USED

Fig. 4 shows the apparatus for weighing the amount of gasoline used. A delicate beam-balance was electrically connected so that it would ring a bell at the beginning and at the end of the consumption of exactly 500 grams or any other desired weight of gasoline. A stop-watch and a tachometer were used to obtain the time and the number of revolutions during which the weighed quantity of gasoline was being used. Readings were taken frequently throughout each test and the gasoline consumption was thus accurately determined within a fraction of 1 per cent.

Before each test the oil-pan was taken off, emptied,

cleaned, wiped out dry and put back. New oil was then supplied. The amount supplied was accurately measured in each case. After the experiment had been finished the oil was drained out and carefully measured to determine the exact amount used during the test. The explosion-chambers were examined before each test and carbon was removed, if present in any appreciable quantity.

Tests were run alternately with and without the duct for running the air through the crankcase, assuring similar conditions. All conditions were held the same for all tests. The conditions were that the speed should be held at 700 r.p.m.; an average of about 8.5 hp. should be applied; the throttle should be opened wide so as to assure the same opening for all tests; and the spark should be set at full-advance position. The carbureter was carefully adjusted to give the same mixture in every case. To obtain this, an adjustment, giving the maximum speed for a given torque, was made, and the mixture then was made lean to a point at which the speed just began to decrease. This gave a mixture-ratio most like that used in practice for maximum power, yet enabled a definite position on the rather flat-crested power-

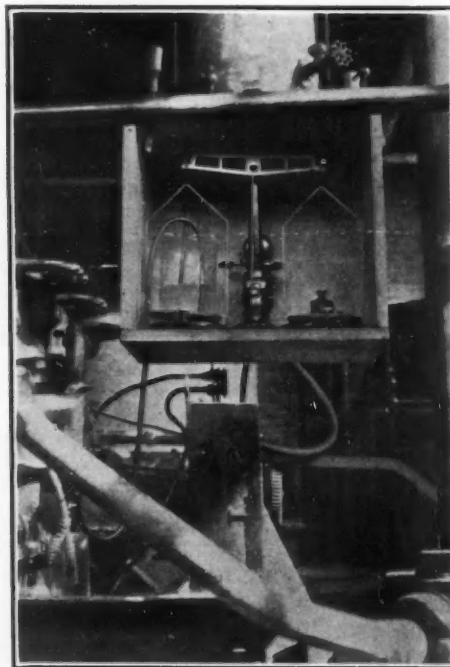


FIG. 4—APPARATUS USED TO WEIGH THE GASOLINE

A Delicate Beam-Balance Was Electrically Connected So That It Would Ring a Bell at the Beginning and End of the Consumption of Exactly 500 Grams or Any Other Desired Weight of Gasoline. A Stop-Watch and a Tachometer Gave the Time and the Number of Revolutions During Which the Weighed Quantity of Gasoline Was Being Used

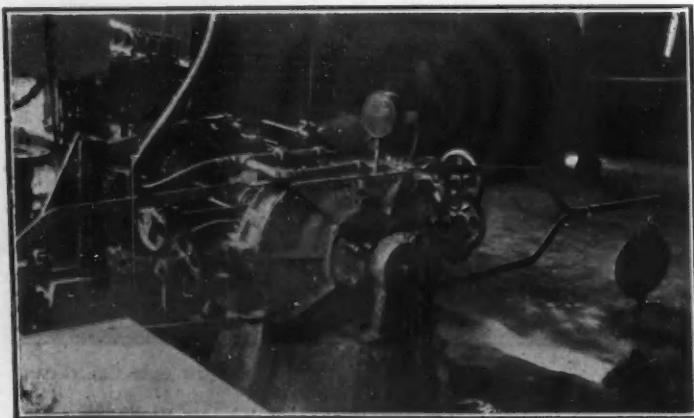


FIG. 3—THE HYDRAULIC BRAKE USED TO SUPPLY THE LOAD
This Brake Is a 14-In. Size and Was Used in Connection with a Six-Cylinder Engine

curve to be obtained. Much care was exercised in getting this adjustment accurately, regardless of the gasoline-consumption. The adjustment was always made after the engine had been well warmed-up.

A medium oil was used throughout all the tests. In the viscosity tests the oil was held at a temperature of 100 deg. fahr. and the time, in seconds, was noted for the flow of 200 cc. of oil through the orifice of an Engler viscosimeter.

RESULTS OF THE TESTS

The first tests served to indicate the feasibility of the ventilating proposition and the results were very en-

A SOLUTION OF THE DILUTION PROBLEM

45

couraging. As is shown by the curves reproduced in Fig. 5, the oil-dilution was very much less than when no ventilation of the crankcase was used. Seventeen tests were run independently. The first 12 tests were run alternately with and without ventilation to get confirmatory results. During these first 12 tests, it was found that more oil was used when ventilating the crankcase than when not. This was assumed to be due partly to the oil's being carried in suspension into the carbureter.

TABLE 1—SUMMARY OF TEST RESULTS

Test No.	Gasoline Consumed, Gal.		Oil Consumption				Drop in Viscosity, Sec.
			Per Hr.		Per Hp-Hr.		
	Per Hr.	Per Hp-Hr.	Cc.	Pt.	Cc.	Pt.	
3	1.535	0.1740	36.96	0.0782	4.19	0.0089	141.8
4*	1.330	0.1640	152.70	0.3228	18.80	0.0398	23.9
5 and 6	1.442	0.1722	101.60	0.2146	12.30	0.0260	115.0
9 and 10*	1.610	0.1904	166.60	0.3520	19.70	0.0417	37.0
11 and 12	1.443	0.1705	96.50	0.2035	11.40	0.0241	112.0
15*	1.595	0.1900	167.00	0.3530	19.90	0.0420	49.5
17A	1.461	0.1816	.....	.....	.....	.....	.....
17B*	1.220	0.1605	.....	.....	.....	.....	.....
17C	1.658	0.2180	.....	.....	.....	.....	.....
17D*	1.302	0.1760	.....	.....	.....	.....	.....

* Ventilation was used in these tests and the air was drawn through the crankcase to the carbureter. Tests not so marked were run without ventilation, the air being taken directly into the carbureter from the room. Tests Nos. 1, 2, 7, 8, 13, 14 and 16 were not listed in the above table because the results were not absolutely reliable, but in no case were they contradictory.

Attempts were made during the next four tests to substantiate or refute the assumption that the oil is carried into the combustion-chamber while in suspension; also, if the assumption were true, to try to catch and to save this oil. Two methods tried for catching the oil proved unsuccessful, but the third, test No. 15, using a duct or oil-trap, shown in Fig. 6, in which the air reversed its direction twice, was successfully used. The oil was thrown against the intruding wall by centrifugal force and then was collected in a reservoir at the bottom and drained out through a gooseneck tube. During the first 50,000 revolutions of the engine 50 cc. of good oil was caught.

DISCUSSION OF RESULTS

Although some oil was caught in the centrifugal oil-trap, not all the oil that was apparently carried into the carbureter was caught, because when running the air through the crankcase 5.75 per cent more oil was consumed than when not running it through. This percentage being the apparent consumption when the percentage of dilution was allowed for, the actual excess consumption was 2.83 per cent. By catching 50 cc. of this oil in the oil-trap in 50,000 revolutions of the engine, the fact was proved that the oil is carried into the carbureter in the form of spray, or fine droplets. This indicates very strongly that by further experimentation a device similar to the oil-trap could be devised that would catch nearly all this oil. The oil-trap was not so essential at low engine speeds but was absolutely necessary at high engine speeds, to prevent an excess consumption of oil, owing to more oil being carried into the carbureter because of higher air-velocity.

Another point was brought out very strongly in test No. 15, in which the oil-trap was used and 65 cc. of oil was caught. The total consumption of oil in test No. 15 was exactly the same as the total oil consumption of tests Nos. 9 and 10 that were exactly similar to No. 15 except that no oil was caught. This would indicate that,

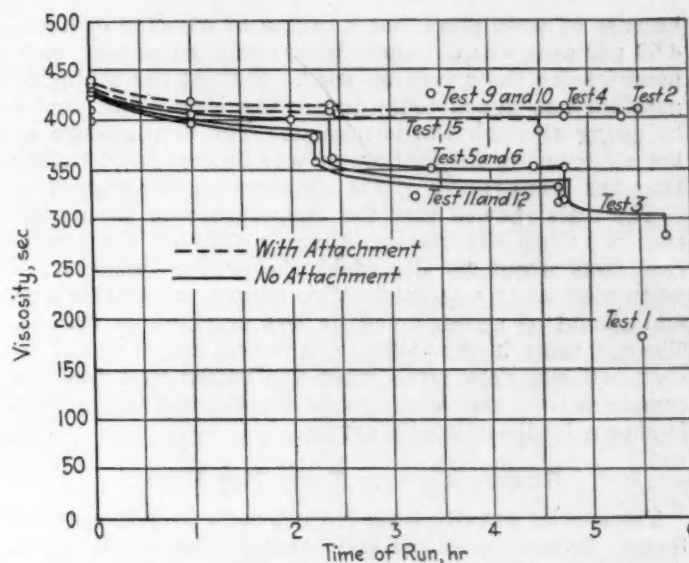


FIG. 5—CURVES SHOWING RELATION BETWEEN THE VISCOSITY AND THE TIME OF RUN

The Two Curves at the Top Were Obtained with the Ventilating Duct in Place and the Remaining Ones without Using It. It will Be Noticed That the Dilution Was Much Less in the Latter Instance. The Abrupt Drops in the Curves Are Caused by Stopping the Engine and Letting It Cool and Condense the Vapors

although some oil is carried into the explosion-chamber, it serves as a lubricant, utilizing the same principle that is used by some motorcycles, in which the cylinders are lubricated by mixing a small amount of lubricating-oil with the gasoline supplied. The oil that was caught seemed to produce no saving in the oil-consumption. This last fact was not confirmed by a duplicate test but serves to indicate that if most of the oil that is carried in the stream of air is caught, the little that does enter the explosion-chamber may serve as a lubricant of the cylinder-walls and not be burned.

An excess of oil amounting to 2.83 per cent was used

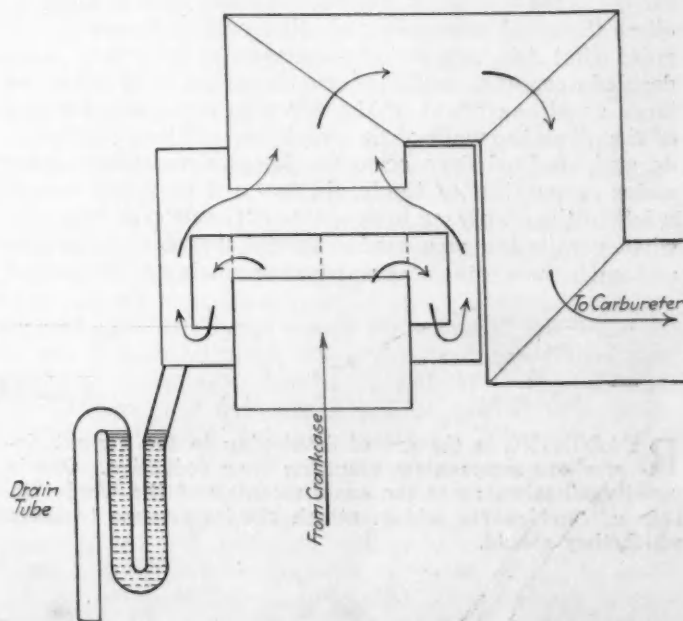


FIG. 6—AN OIL-TRAP THAT SUCCESSFULLY CAUGHT THE LUBRICATING OIL THAT WAS FORMERLY CARRIED INTO THE COMBUSTION-CHAMBER IN SUSPENSION

In This Device the Air Passing Through Reversed Its Direction Twice. The Oil Was Thrown against the Walls by Centrifugal Force and Collected in a Reservoir at the Bottom and Drained off through the Tube at the Lower Left. During the First 50,000 Revolutions of the Engine 50 Cc. of Good Oil Was Caught

because of ventilation, but a saving of gasoline of about 4.50 per cent was obtained which much more than compensates for the excess oil used. Part of the saving of gasoline was undoubtedly due to the air's being heated by going through the crankcase. The temperature of the air entering the carburetor was 50 deg. fahr. higher than the temperature of the air entering the crankcase.

The tests showed that the temperature of the crankcase oil, when the air was running through the crankcase, was about 20 deg. fahr. below the temperature when ventilation was used. This assures cooler bearings and should be accompanied by less cracking of the oil. The difference in the viscosity of the oil before and after each test was very small when ventilation was used, as compared with that when no ventilation was used. This is shown by the viscosity curves.

SPECIFIC-GRAVITY TESTS NOT USED

The specific-gravity tests did not seem to give a satisfactory indication of the difference of the condition of the oil. For that reason they were not used; but the viscosities that seemed to indicate directly the condition of the oil were used. Samples of oil were taken before and after each test. In some tests a sample was taken at the end of each hour's run, after stopping while the engine was still hot and after the engine became cold. Tests of these oil samples showed that the viscosity dropped rapidly until the engine became warmed-up. After becoming warmed-up the viscosity remained almost constant until after the engine had been stopped and allowed to cool-down. This rapid dropping of the viscosity at the start, with the engine cold, was evidently due to the cold cylinder walls' condensing the gasoline rapidly, and leaking more freely past the piston-rings, until they became heated and expanded. The tests of the oil also showed, on the viscosity curves at the end of a run, that the viscosity dropped straight down a considerable distance, due to the condensation of the vapor in the crankcase when cooled, and also to the draining down with the oil to the oil-pan, of the fuel held in suspension in the oil on the crankcase walls and other parts. It was at this point that the greatest viscosity-drop occurred. This decided drop of viscosity of the oil served to indicate the large gasoline-content of the vapor in the crankcase and of the oil on the walls of the crankcase. When ventilated, no such decided drop occurred, because ventilation promotes evaporation of the liquid fuel and very little vapor is left in the crankcase to condense. The drop of viscosity when ventilation was used occurred largely at starting and until the engine was warmed-up, owing to more fuel

coming into the crankcase under these conditions.

The cracking of the oil plays a minor part in diluting the oil; otherwise a much greater oil-consumption would occur. Also, if the oil cracked excessively the remaining oil, or heavy ends, would show a large increase in viscosity, provided that the light ends did not remain to dilute the heavy ends. When ventilated, the oil did not increase in viscosity, or decrease greatly.

Another thing that would be necessary under service conditions is to keep the road dust from entering the crankcase. Road dust, when drawn into the explosion-chamber, unites with the carbon, forming a very hard and good abrasive. This shortens the life of the piston, the piston-rings and the cylinder-walls very materially. Air-washers have been common in England, to prevent road dust from entering and abrading the cylinders. More than 26 different kinds of air-washers are at present on the market, about 12 using the dry method, 12 using water and the remainder utilizing oil. From these a satisfactory cleaner could be selected. The one essential, besides cleaning the air, that the cleaner selected must have, is the minimum resistance to the flow of air.

SUMMARY

Tests show the dilution of the crankcase oil that takes place with and without the attachment. Much less oil-dilution occurred when ventilation was used; also less gasoline. But more oil was consumed. Further tests indicate that a large percentage of the extra oil-consumption was caused by oil, in the form of a fine spray, being carried with the air into the carburetor. This oil was caught by the oil-trap, utilizing centrifugal force, and was found to be of good quality. Quantitative values seem to indicate that only part of the oil carried by the air into the explosion-chamber was burned, the remaining part serving as a lubricant in the cylinder.

This method of solving the crankcase-oil-dilution problem requires only an inexpensive apparatus and operates with negligible power, there being no wear and practically nothing to get out of adjustment. It serves the purpose of almost entirely eliminating crankcase-oil dilution and in addition effects a saving in the cost of operating the engine, because of a smaller consumption of gasoline.

The results obtained from the tests are not conclusive, as they were run on one engine only; and several points brought out by the test indicate the need of additional data, which it is hoped soon to obtain. But the results do indicate that the apparatus used possesses sufficient merit to warrant further investigation.

REASONING

REASONING is the art of developing to the highest degree, the suppositions resulting from deduction. One is usually mistaken as to the exact meaning of the words "to reason," and people seldom attach the importance to them which they should.

One is apt to think that the gift of reasoning is bestowed upon everyone. Perhaps; but to reason, following the principles of justice and truth, is an operation that can be performed only by minds endowed with common sense.—Yoritomo-Tashi.



Water in Crankcase Oils

By A. LUDLOW CLAYDEN¹

SEMI-ANNUAL MEETING PAPER

Illustrated with PHOTOGRAPHS AND DRAWING

DESCRIBING the three ways in which water may reach the oil-pan, the author says that the danger-point for water accumulation is reached where an emulsion becomes too highly viscous or when an accumulation of free water reaches the pump intake. The effect of using an emulsifying oil is explained and consideration is given the amounts of water actually deposited because of cylinder-wall condensation. An emulsion of oil with water up to 5 or 6 per cent differs hardly at all from the pure oil so far as film-forming and lubricating qualities are concerned. On the other hand, with an oil that is absolutely non-emulsifying, the tendency is for the water to segregate and collect in comparatively large globules. The ability of an oil to absorb a small percentage of water has the advantages of minimizing the danger of complete failure of oil circulation when starting in cold weather, and of reducing somewhat the rate of piston-ring and cylinder-wall wear.

Experimental work that enables the rate of deposition of water to be determined was done by the company the author represents, a special engine being constructed for this purpose. Illustrations of the engine and the testing apparatus are presented and a description is included. The work has been continued for many months. Numerous check-runs have indicated that the rate at which water appears in the cylinder oil is shown by a straight-line graph between 35 and 110 deg. fahr., the deposition ceasing at the latter temperature. When continued below 35 deg. fahr. in the same straight line, the graph shows that at 0 deg. fahr. the rate of deposition would be 80 cc. per hr.

IN addition to dirt and heavy ends of fuel, the accumulation of water is formed of oil contamination that must be reckoned with. By the use of an emulsifying oil, a certain small proportion of water present in the lubricant will have no effect upon either its viscosity or its coefficient of friction. With an oil that will not emulsify, the water will do no harm provided it is trapped in the pan in such a manner that it cannot enter the pump suction. The danger-point is reached when either an emulsion becomes too highly viscous or an accumulation of free water reaches the pump intake.

Water reaches the oil-pan in three ways. When the products of combustion leak past the pistons, water vapor, at a temperature between 200 and 400 deg. fahr., will enter a crankcase atmosphere of about 130 deg. fahr.; consequently, the major portion of the leaking gases will condense since the principal product of the combustion of gasoline is water.

When a cold engine is first started, the crankcase air is very quickly heated by the undersides of the piston-heads. The warm air will deposit some moisture as it comes in contact with the cold oil, the cold sides of the crankcase and the walls of the oil-pan.

Most important of all, considerable direct condensation of water occurs in the working part of the cylinder so long as the water in the jacket is below 100 deg.

fahr. Such deposition is, of course, slight in warm weather, but it accounts for the bulk of the water formed in winter operation of automobiles.

It is claimed that certain of the filtering schemes using woven material will extract water; if they do so efficiently, the water problem is solved, especially when oil-pans are arranged so that a reasonably large trap is provided. Still, it is doubtful whether either filtration or trapping or both together would enable the same oil to be employed for long periods of winter running. Once oil temperature is raised above 100 deg. fahr., with the oil in circulation, any water present in the form of emulsion is driven off. Thus, under summer conditions of driving, some water will be formed each time the engine is started, and the effect of leakage past the pistons is, of course, much the same whatever the atmospheric temperature. Since the engine temperature in normal operation will be over 150 deg. fahr., and the oil temperature at least 120 deg. fahr., the lubricant will reject water faster than it is supplied.

EFFECT OF USING AN EMULSIFYING OIL

Neglecting, for the moment, methods of extracting the water mechanically, and assuming a strictly conventional automobile lubrication system, the effect of using an emulsifying oil deserves further explanation. An emulsion is more viscous than the pure oil, but not sufficiently so to interfere with normal operation, at least unless the amount of water exceeds 10 per cent. An average automobile crankcase contains 6 qt. of oil and an emulsifying oil can absorb and hold 19 oz. of water or a little over 1 pt. It will be shown later that the presence of so large a quantity of water is not unreasonable to expect.

One of the principal claims made for emulsifying oils is that by absorbing the water they prevent the formation of cakes of ice. Ice is harmless so long as it is contained in a trap but, if an engine is allowed to stand with enough free water to enter and fill the pump, the freezing therein will lock the pump and choke its intake. If an engine is started in this condition there is danger of shearing the pump drive; and, even if the latter is strong enough to break the pump free, the intake and screen will usually remain choked until thawed out. This means that the engine will be operating entirely without oil for an indefinite period.

If a similar quantity of water is contained in the oil in the form of an emulsion, the action will be different. Severely chilled emulsions reject the water they contain, but the rejection will take place at temperatures below the freezing-point of water. Thus, by chilling a crankcase full of emulsified oil, the water is converted to ice as rapidly as it is rejected. This means that the ice is formed in crystals of microscopic size and, the cold oil being highly viscous, the ice particles remain in suspension. With low percentages of water, the effect will be that of increasing the viscosity and, when the water content is just about equivalent to the oil's maximum absorbing ability, the effect of severe

¹ M.S.A.E.—Chief engineer of gas-engine research, Sun Oil Co., Philadelphia.

chilling will be to produce a mush. Such a mush cannot lock the pump gears nor can it solidly block the pump intake. It can be so thick that it will not flow *freely* through a pump screen, but it will not entirely stop oil circulation even though it may restrict it. The most important advantage of having the water in emulsion when starting from extreme cold is that full circulation will be obtained rapidly. This is because the mixture of oil and water thins steadily as its temperature rises. As the oil warms from say zero up to 20 deg. fahr., the amount flowing will increase from something perceptible up to a considerably larger amount. No sudden change occurs as with a frozen pump-intake, with which no flow can take place whatever until the oil is above 32 deg. fahr.

So far as ease of starting in cold weather is concerned, the value of an emulsifying oil is slight; but it has a distinct advantage because, with it, the danger of complete cessation of oil-flow is removed so long as the water accumulation is not allowed to exceed the proportion that the oil can readily absorb.

CYLINDER-WALL CONDENSATION

So far, the advantages of emulsification have been considered only from the viewpoint of its effect upon oil-flow. However, the bulk of the water that gets into the oil-pan is formed by direct condensation on the internal walls of the cylinders, and this introduces another consideration altogether.

The descending piston uncovers a surface of oil-coated iron at a temperature only a few degrees greater than that of the water in the jacket. With a water temperature of 150 deg. fahr., or more, the inner wall of the cylinder may be very considerably hotter than the water itself, but at low temperatures the difference is very slight. During most of the power stroke and all the exhaust stroke, the cylinder is filled with gases of which the largest part is water vapor. Experimental work has shown that during the power and the exhaust strokes the time is sufficient for a perceptible amount of water to be condensed within the cylinder. Water so formed does not escape with the exhaust gases; it remains in the cylinder and finds its way into the oil-pan.

The method for determining experimentally the quantity of water formed will be described later; meanwhile some consideration may be given to the amounts of water actually deposited. Using a cylinder of approximately normal automobile size and assuming a water-jacket temperature of 10 deg. fahr. at starting, the rate of deposition of water in each cylinder of the engine is about 1 cc. per min. average, as the engine warms-up from 10 deg. to 100 deg. fahr. Under the most favorable conditions, this means a total of 10 cc. per cylinder before the engine is warm enough for the deposition to cease. Assume that the average speed of the engine is 1000 r.p.m. during its warming-up period. The water deposition takes place during two strokes, the power and the exhaust. The oil-film is placed on the cylinder by the up-stroke of the piston during compression; this film is exposed during the two strokes succeeding and is replaced as the piston ascends while exhausting. At 1000 r.p.m. there will, of course, be 500 water-depositing periods; so, the volume of water deposited during each may be taken as 1/500 cc. The volume of oil spread over the cylinder wall at each piston up-stroke can only be estimated. It is highly improbable that the film thickness exceeds 0.01 mm. 0.000397 in., in which case the total volume of oil spread

over the surface exposed to water deposition would be approximately 0.25 cc. On this basis, the volume of water laid down in any one period of deposition would be a little less than 1 per cent of the volume of oil present. If, therefore, we assume that the film thickness is much less than the 0.01 mm. (0.000397 in.), a bulk of oil far exceeding that of the water still remains.

The water must be deposited upon the oil-film in the form of a cloud; that is, an almost infinite number of extremely minute particles. With an oil capable of dissolving a small percentage of water, the emulsification of the water would be instantaneous as the piston rose. An emulsion of oil with water up to 5 or 6 per cent differs hardly at all from the pure oil, so far as film-forming and lubricating qualities are concerned. On the other hand, with an oil that is absolutely non-emulsifying, the tendency is for the water to segregate and collect in comparatively large globules.

EFFECTS ON LUBRICATION

If cylinder or piston lubrication were perfect; that is, if the lubrication were as good as it can be in an ideal bearing with no metallic contact whatsoever between piston-rings and cylinder wall, it probably would make little difference whether the small percentage of water existed in the free state or as an emulsion. But the rapidity of piston-ring wear is proof that lubrication is far from complete. Also, during the cold-wall period, when water deposition is most rapid, the deposition of heavy ends of fuel is also at a maximum, and these have a powerful solvent action on the oil-film. The natural imperfection of the lubrication, plus the oil-dissolving effect of the diluent, means that parts of the cylinder wall are actually exposed on the power stroke. With non-emulsifying oil, the water will tend to accumulate in these exposed spots and, by wetting them, will make the re-establishment of an oil-film more difficult.

It may be granted that the effect of fuel diluent in washing the oil-film from the walls is of greater effect in accelerating wear than is the deposition of the small amount of water involved; but the latter cannot be entirely neglected. While it may be difficult to place a precise value in terms of reduced wear upon an emulsifying property in the oil, the fact that it must be of assistance is incontestable.

Summing up, the ability of an oil to absorb a small percentage of water has the advantages of minimizing the danger of complete failure of oil circulation when starting in cold weather, and of reducing somewhat the rate of piston-ring and cylinder-wall wear.

One objection to providing oil with the emulsifying property is that an emulsion will carry solids in suspension more easily than a pure oil will. However, this applies only to very thick emulsions, much richer in water than would be existent in a crankcase oil. An emulsion will exist long in an engine oil only when the temperature of the oil remains well below 100 deg. fahr., and such a condition can occur only when the atmospheric temperature is well below the freezing-point. Under these conditions the outside of the oil-pan will be cold, and the oil in contact with the inside will also be maintained at the same low temperature. Inside an oil-pan at 32 deg. fahr. is a skin of oil at essentially the same temperature. This skin will be highly viscous and will tend to remain adhering to the walls, all circulation taking place with oil nearer the center of the pan. Assuming the engine to be reasonably warm when it is stopped, the larger and more injurious solids will settle to the bottom before the oil has cooled. The viscous film that will

stick to the oil-pan walls during the subsequent starting and warming-up period will therefore tend to hold the solids where they lie and prevent them from being drawn into circulation; so, whether the oil will emulsify or not, the solids are fairly well taken care of during the period of operation when an emulsion of any degree of richness can exist.

DETERMINATION OF WATER-DEPOSITION RATE

The experimental work that enables the rate of deposition of water to be determined was done with a special engine shown in Fig. 1 that was constructed for the purpose by the Sun Oil Co. It has a single cylinder of 3½-in. bore and 5-in. stroke. The cylinder is literally cylindrical, with a flange at each end; it is machined all over. The valves are in the head, which is a separate casting bolted to the top flange of the cylinder.

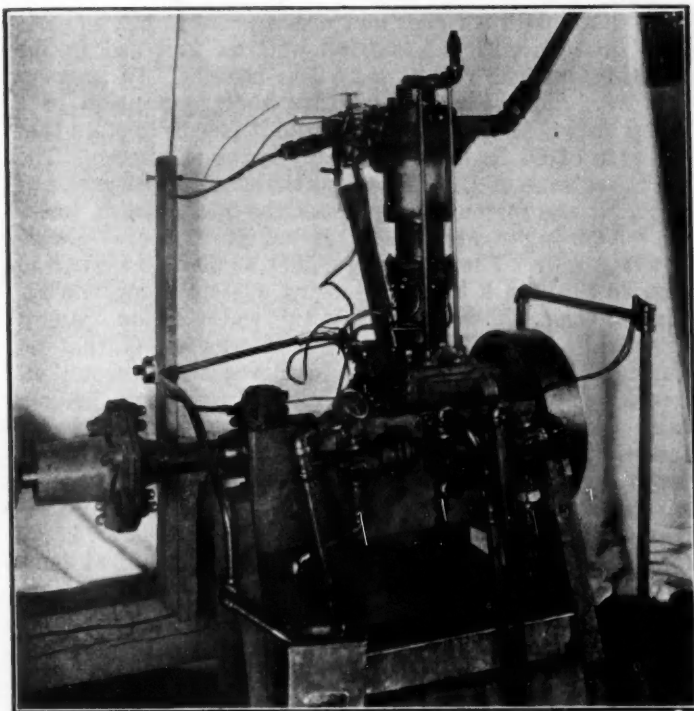


FIG. 1—COMPLETE ENGINE AND ATTACHMENTS BY WHICH THE DEPOSITION OF WATER ON THE CYLINDER WALLS WAS MEASURED

This Engine Had a Single Working Cylinder with a 3½-In. Bore and a 5-In. Stroke Which Was Machined All Over and Had a Flange at Each End. The Valves Were in the Head, Which Was a Separate Casting That Was Bolted to the Top Flange of the Cylinder. The Piston Was of the Split-Skirt Design with Four Narrow Cast-Iron Rings. The Working Cylinder Was Mounted on Top of a Second Flanged Cylinder That Was Separated from the Working Cylinder by a Ring of Insulating Material 1 in. Thick and Had a Plain Aluminum Piston without Rings That Acted as a Crosshead. The Working Piston Was Joined to the Crosshead by an Articulated Connecting-Rod, This Arrangement Permitting the Use of a Conventional Working Piston with a Wristpin and also Corrections for Small Errors of Alignment between the Working and Crosshead Cylinders

An alloy piston of the Aluminum Co.'s standard split-skirt design is used with four narrow cast-iron rings.

The working cylinder is mounted on top of another flanged cylinder, the two flanges being separated by a ring of insulating material 1 in. thick. In the lower cylinder is a plain aluminum piston without rings, which acts as a crosshead. An articulated connecting-rod joins the working piston with the crosshead, the object of this being to permit the use of an entirely conventional working piston with wristpin and also to correct for small errors of alignment between the working and the cross-head cylinders.

This piston-rod passes through an inverted copper

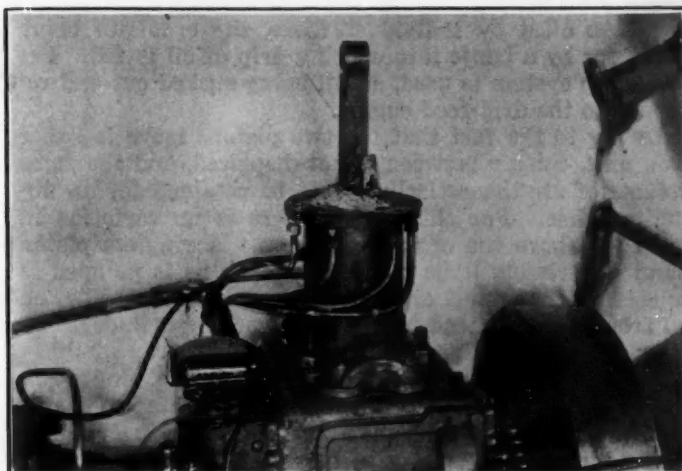


FIG. 2—THE INVERTED COPPER FUNNEL ON WHICH THE CYLINDER OIL WAS CAUGHT

This Funnel Surrounds the Piston Rod and Has a Flanged Rim. It Is Placed Directly Underneath the Insulating Rim That Separates the Two Cylinders and Is Clamped in Place by the Through-Bolts That Unite the Two Cylinders and the Insulating Ring. Any Liquid Descending the Wall of the Working Cylinder Will Be Caught on the Funnel and Conducted toward the Outer Edge where a Series of Drain-Holes Are Located

funnel with a flanged rim as shown in Fig. 2. This is located immediately beneath the insulating ring that separates the cylinders and is clamped in place by the through-bolts that unite the two cylinders and the insulating material. It will be seen that any liquid descending the wall of the working cylinder will be caught on the funnel and conducted toward its outer edge, where drain-holes are located.

The crankcase is conventional and the crankshaft bear-

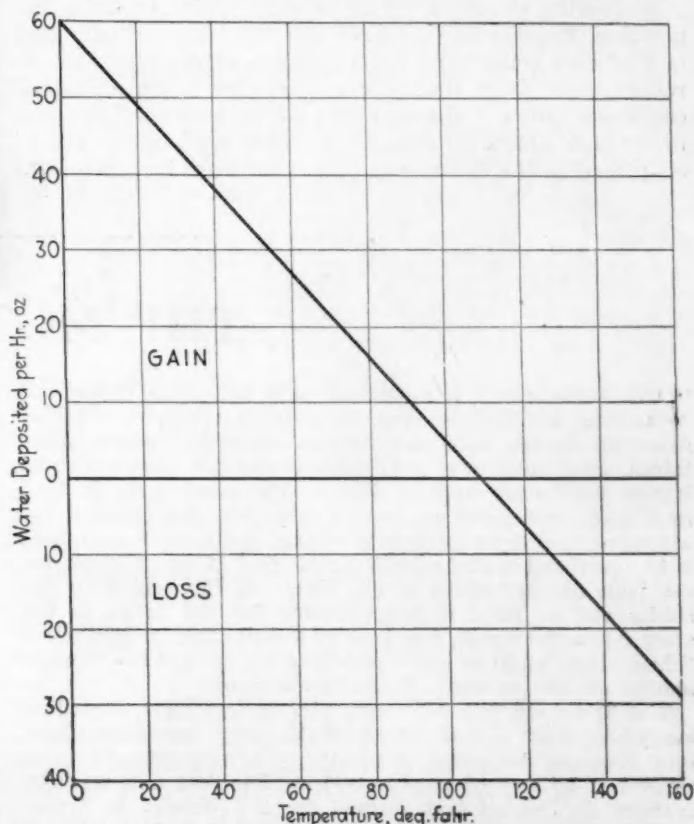


FIG. 3—RATE OF DEPOSITION OF WATER ON THE CYLINDER WALLS OF AN AVERAGE-SIZE ENGINE AT VARYING TEMPERATURES

The Portion of the Oblique Line between 35 and 110 Deg. Fahr. Is Based on the Results of Numerous Check-Runs. The Portion between 0 and 35 Deg. Fahr. Is a Logical Extension of the Graph of Observed Results and Shows That at 0 Deg. Fahr. the Rate of Deposition Would Be 80 Cc. per Hr.

ings are oiled by individual feeds, the crankpin being cared for by a banjo into which a drip of oil is fed. The dry-sump system is used, all oil being sucked out and returned to the drip-feed supply.

Owing to the fact that the two pistons move together as a unit, the air between is not displaced, and the same volume of air theoretically would be retained for an unlimited time. For this reason there is no variation in pressure above the crosshead piston. A ringless piston pumps extremely little oil and so much as is pumped is caught on the funnel and deflected back; so, literally, no oil from the crosshead reaches the working cylinder. To lubricate the working piston, a very fine spray of oil is injected through an orifice in the insulating ring. Six copper pipes of 5/16-in. diameter are connected to drain-holes that draw off the oil from the working cylinder. These pipes go to a header and then a single pipe of 1/2-in. diameter returns to a small tank from which the spray pump takes its supply. By these means the cylinder oil is circulated and kept quite independent of the crankcase oil.

For the working cylinder, a detachable copper water-jacket sealed by rubber rings is provided. The water-pump is placed between the engine and the outlet so that it sucks water through the system instead of forcing it. The object of this departure from ordinary practice is to create a pressure below atmospheric pressure within the jacket and so cause the rubber rings to tighten automatically. Water enters the cylinder and leaves the jacket near the top, thence it passes around the bulb of a recording thermometer and goes back into the cylinder-head, from which the pump draws it and discharges to the tank.

In making the runs for the determination of water deposition, the engine was first run until the cylinder and piston were considered a practically perfect fit. The oil-return pipes from the cylinder were led to an ice-cooled condenser, so that the oil delivered back to the tank was in no case above 50 deg. fahr. Measured quantities of oil placed in the cylinder-supply tank were then found to

remain unchanged for a run of 1-hr. duration, proving that none was being lost by evaporation and that the quantity pumped by the piston was so small as to be negligible. Numerous repeat-runs were made at water-jacket temperatures ranging from 35 to well above 100 deg. fahr. The fuel employed was a very light gasoline, so as to eliminate the effect of dilution which would have complicated the observations and served no useful purpose. The work has been continued over a period of many months, and numerous check-runs have shown that the rate at which water appears in the cylinder oil is shown by a straight-line graph between 35 and 110 deg. fahr., the deposition stopping at the latter temperature. It is entirely logical to assume that this graph can be continued below 35 deg. fahr., as illustrated in Fig. 3, in the same straight line, which indicates that at zero the rate of deposition would be 80 cc. per hr.

These runs were all made with a lean mixture. Check-runs made with a richer mixture, a mixture more nearly like the conventional one, showed an increase in deposition, but the results were less regular. In no case, however, did the richer mixture show deposition at a lesser rate than the lean setting, so it is safe to state that the rate of 80 cc. at 0 deg. fahr. is the minimum. The fact that none of this water is attributable to leakage of gas past the piston is proved by the cessation of water deposition in the oil when the jacket temperature exceeds 100 deg. fahr. The oil, being chilled to 50 deg. fahr., and carried through a long condensing system before its return to the tank, would liquify any water vapor present. Practically, in making the runs, it was found that no difference in water collection occurred with the oil allowed to reach 75 deg. fahr., but approximately 50-deg. fahr. temperature was maintained to be sure. It is interesting to observe, in connection with the cessation of water deposition at 110 deg. fahr., that it is often necessary in refinery practice to dehydrate oil; this can be accomplished by blowing the oil with compressed air, keeping the temperature at 120 deg. fahr. Blowing at temperatures below 100 deg. fahr. will not effect separation.

THE MOTOTERIA

THE mototeria is a serve-self store on wheels capable of serving 400 families per day with a complete stock of groceries, breads and cakes, fruits, green and staple vegetables, meats and drug sundries. It has but one clerk, who is also cashier as well as driver. His store is 22 ft. long by 7 1/2 ft. wide, yet so conveniently are the commodities arranged, each with its own price tag, and so easy to operate is the overhead basket carrier device that 10 or 12 customers can wait on themselves at one time. If the housewife has babies and no help, it is impossible for her to go to the store down the street, but here is a well-stocked, low-priced "chain store" right at her door where she can get her "items" and be out of the house but a few minutes.

The first unit was built and stocked complete, including everything that a chain store would carry, but having several features borrowed from the old neighborhood shop thrown in by way of good measure. The first unit was put to work in Detroit last August for the Wright & Parker Stores, a chain comprising 80 units, the Federal Motor Truck Co. furnishing the 2 1/2-ton chassis for the trial. The Wright & Parker Co. was open-minded enough to want to find out if this was really a better method of food distribution to city dwellers.

The shoppers took it up immediately. While they had

appreciated the chain store with its lower prices, yet they had to carry the goods some distance, which was usually a bother. Here was a store that was lighted and heated, neat, clean and sanitary; but best of all with everything needed for breakfast, lunch or dinner and with good savings in each item.

While the average chain-store receipts were under \$500 a week, the mototeria started doing a \$1,000-a-week business before it had been long on the route. Further, by a reduction in clerk hire and savings in rent, light, heat, window displays and other items, the profit increased from 3 to 12 per cent, even when the retail prices were kept equal to the chain-store prices. Instead of drawing an indifferent trade from a radius of from three to five blocks, this store visited the families in from 35 to 40 blocks every day. It was found that the turnover possible by increasing the number of customers was almost unheard of in the grocery or meat trade.

The mototeria carries assorted meats, but mostly cold meats for immediate use, because of the lack of cutting facilities. Its meat order system, however, is a great convenience and saving to both the operator and the customer. Meats are ordered one day for the next.—B. J. Duncan in *Forbes*.

Rectification of Diluted Crankcase-Oil

By RALPH L. SKINNER¹

SEMI-ANNUAL MEETING PAPER

Illustrated with **DRAWINGS AND PHOTOGRAPHS**

IT is generally recognized that the dilution of crankcase-oil with water and unburned fuel tends to accelerate the wear of engine bearings, cylinders and pistons. The author traces the engineering development of a rectifying device and system designed to combat this problem. In this system, diluted oil that tends to work-up past the pistons, in company with the water vapor and unburned fuel that tend to work down into the crankcase, is drawn from the cylinder walls and pistons by vacuum. This diluted oil is conducted into a still or rectifier where it is subjected to heat from the engine exhaust. The heating action is just sufficient to volatilize the fuel and water, the resulting vapor being returned to the intake-manifold and thence to the engine where it is burned. The lubricating oil that remains behind is conducted back into the crankcase. The system functions automatically. A float-actuated mechanism controls the flow of the diluted oil through the rectifier, and a thermostatically-controlled valve regulates the degree of heat to which the liquid is subjected.

Troubles encountered in the early stages of development of this device and the means employed to overcome them are described. Temperatures prevailing throughout the system when it is in operation are given. Data relating to the volume of oil handled by the device in ordinary service are presented.

Comparative tests to determine engine wear with and without the device are described. In one of these, dust was intentionally introduced into the intake-manifold to determine whether it was detrimental to engine life when dilution was and was not present. Based on these and other test results, the author expresses the opinion that an ordinary amount of dust is not harmful if the oil is maintained at somewhere near its initial viscosity by a rectifying device. Relative wear data are presented in curve form.

Crankcase-oil dilution is one of the main obstacles to be overcome before fuels of low volatility can be burned satisfactorily in automotive engines of the present day. The author states his belief that the use of a rectifying system to drive off the diluents from the lubricating oil and prevent their reaching the crankcase will assist in conserving the supply of petroleum fuels.

EXTENSIVE tests have demonstrated that dilution of crankcase oil is the greatest contributing factor to wear in internal-combustion engines. If dilution is prevented and the viscosity of the lubricating oil is thereby kept up to standard, wear will be reduced to the minimum even under service conditions where dust is freely encountered during engine operation. It is only natural that an attempt should have been made to solve this serious problem. In this connection, I have worked along the lines pursued by several other investigators in their endeavors to correct this trouble.

My first device was constructed to drive out the diluent that had accumulated in the crankcase of an engine, by using the intake vacuum to draw off the oil from the crankcase, passing it through a heater that

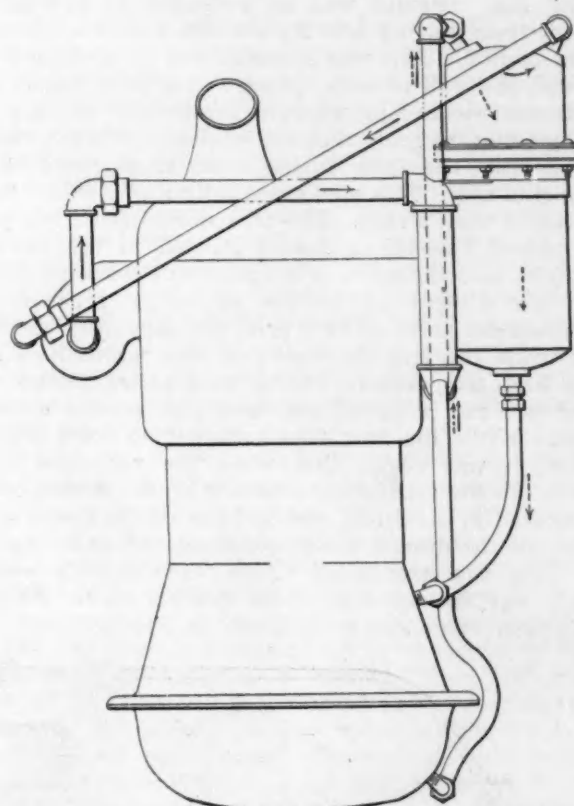


FIG. 1—THE FIRST DEVICE DEVELOPED TO SOLVE THE DILUTION PROBLEM

In This Construction the Diluted Oil That Had Accumulated in the Crankcase Was Drawn Off by the Intake Vacuum, Passed through a Heater in the Exhaust-Manifold and Then Run through a Separator or Trap, from Which the Refined Oil Was Returned to the Crankcase, and the Diluent That Had Been Removed by Heat Was Taken into the Intake-Manifold.

was placed in the exhaust manifold, and thence to a separator or trap from which the refined oil was returned to the crankcase of the engine. The diluent removed by the heat was taken into the intake-manifold of the engine as a vapor. This system was found to be very unsatisfactory for many reasons, the principal one being that on short trips, in which dilution is more pronounced and choking from frequent starts deposits an unusual quantity of gasoline in the crankcase, it was necessary to have some outside means other than the heat of the engine exhaust to drive off the diluent that had already accumulated. This, of course, was impossible and impracticable. Another reason was that when the dilution had reached 15 or 20 per cent, it was necessary to handle all the oil in the crankcase from 10 to 15 times to bring the oil back to anywhere near its original viscosity. If it had been possible to take the contaminated oil out of one compartment and deposit it in another, it would have been possible to drive out practically all the diluent by one handling of the oil. But it can be appreciated readily that when the refined oil was returned into the original body of oil, the dilution of the

¹ M.S.A.E.—President and manager, Skinner Automotive Device Co., Inc., Detroit.

total mass was reduced but a very small amount by each passage of the oil through the system. Another objection was the fact that a great amount of heat was required to drive out the heavy ends of the fuel. This heat resulted in coking or carbon formation in the heater itself. A drawing of this original system is shown in Fig. 1.

ATTEMPT MADE TO REMOVE DILUENT AT THE PISTONS

The next attempt was an endeavor to prevent the diluent from getting into the crankcase oil and the sump of the engine. This was accomplished by drilling a hole through the wall of each cylinder at a point adjacent to the lowest piston-ring when at the bottom of its stroke and by using the suction of the intake-manifold to remove the oil from the space in the lower ring-groove behind the piston-ring. This was essentially a preventive measure rather than a cure. The oil removed from this point was passed through a heater located in the exhaust-manifold, and thence to a device that separated the oil from the diluent as in the preceding arrangement. Dynamometer tests of this principle gave very good results while the trap or separator was maintained at a fairly high temperature, but, as soon as the method was tested on a car in actual use, very poor results were obtained. While the heat was sufficient to drive out the diluent, it was found that when the vaporized gases passed into the separating chamber of the device, which was located in the direct cooling-blast of the fan, a great portion of the diluent would condense and again be carried into the crankcase. Also, considerable carbon trouble was encountered in the heater, as in the preceding test. This system is shown in Fig. 2.

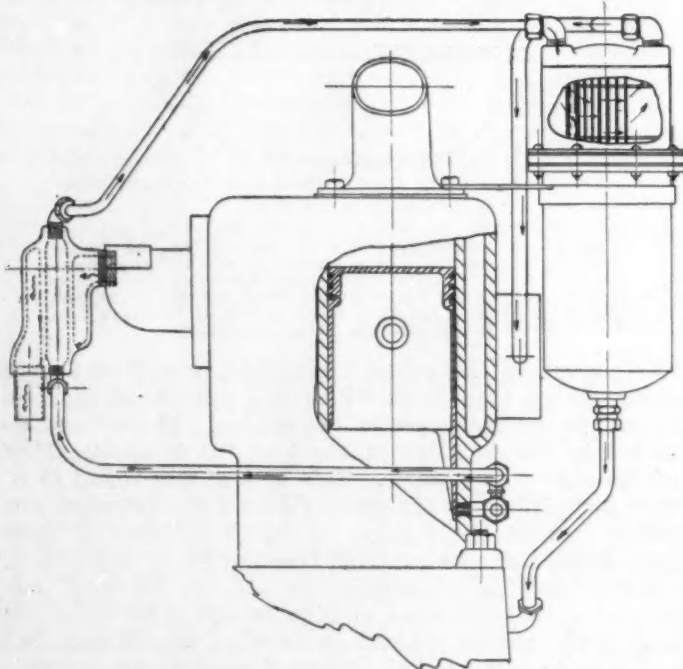


FIG. 2—THE NEXT STEP IN THE DEVELOPMENT

By Drilling a Hole through the Cylinder Wall of Each Cylinder at a Point Adjacent to the Lower Ring of the Piston at the Bottom of the Stroke, an Effort Was Made to Prevent the Diluent from Getting into the Crankcase Oil or the Sump of the Engine. The Suction of the Intake-Manifold Was Used to Remove the Oil from the Lower Ring-Groove of the Piston in the Space Back of the Piston-Ring. The Oil Was Passed through a Heater That Was Located in the Exhaust-Manifold and then to a Separator as in the Earlier Construction. While This Device Gave Very Good Results when Used with a Dynamometer, the Results Obtained in Actual Use on a Car Were Very Poor. The Heat Was Sufficient to Drive Off the Diluent but when the Volatilized Gases Passed through the Separating Chamber, Which Was Located in the Direct Cooling Blast of the Fan, a Large Portion of the Diluent Would Condense and Be Returned to the Crankcase. Considerable Carbon Trouble Was Also Encountered in the Heater

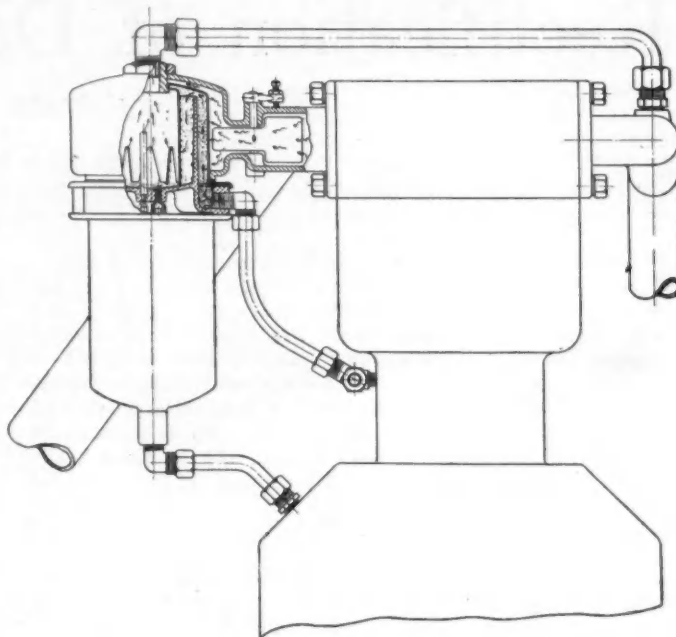


FIG. 3—THE THIRD FORM OF DEVICE IN WHICH THE HEATER AND THE SEPARATOR WERE COMBINED

In This Construction the Oil That Was Removed from the Sides of the Piston Was Conducted to a Compartment That Was Subjected to Heat when the Separation of the Diluent and the Oil Took Place. Although Excellent Results Were Secured, when an Engine Was Subjected to Long Continuous Operation at High Speed and an Abnormal Amount of Heat Was Available, the Oil Formed a Large Quantity of Carbon as a Result of Being Subjected to This Heat and Its Viscosity Increased

The heater and the separator were combined in our third experiment. The oil that was removed from the sides of the pistons was conducted to a compartment where it was subjected to heat at the same time that the separation of the diluent and the oil took place. This system is shown in Fig. 3. Splendid results were obtained with this principle, but one very serious defect was encountered. When an engine was operated continuously at high speed for a long period an abnormal amount of heat was available. Subjecting the oil to this excessive heat resulted in forming a large amount of carbon and increasing the viscosity of the oil. The oil consumption of the engine also increased very appreciably. By inserting a trap or compartment between the device and the intake-manifold connection, in which a portion of the vapor that was driven off by the heat was condensed, it was demonstrated that the lower fractions of the lubricating oil constituted the largest portion of the parts condensed.

After very many experiments with various automatic and mechanical valves, in an endeavor to eliminate this carbonizing trouble, we finally conceived the idea of using a piece of thermostatic metal that would open a small valve automatically at a predetermined temperature so that the oil removed from the pistons could not be subjected to an excessive amount of heat. This was found to be an ideal arrangement. The results obtained show not only that dilution can be kept down to any percentage desired, but that the oil in the engine will not stiffen, or the viscosity increase. This system will be described in detail, as it is the one used at present in production. It is shown in Fig. 4.

DETAIL DESCRIPTION OF DESIGN FINALLY ADOPTED

A series of letters is used in the following explanation to enable the reader to follow the path of the oil from the time it is removed from the pistons until it returns to

RECTIFICATION OF DILUTED CRANKCASE-OIL

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the crankcase of the engine. A hole, *A*, is drilled through each cylinder-wall at a point just below the lowest piston-ring when the piston is at the bottom of its stroke; a manifold or busbar, *B*, connects these holes. This manifold is connected with the device by a pipe, *C*. The hole *A* is intermittently placed in register with the longitudinal groove *D* which is connected with the lower piston-ring groove. This longitudinal groove *D* permits the intake suction to be applied to the ring-groove for a long period of the stroke of the engine. In most cases we find that the vacuum is applied to the lower ring-groove during from 110 to 180 deg. of a revolution of an engine, depending entirely upon the length of the stroke.

The small hole *E*, drilled inwardly through the piston wall to its interior, is a very important factor in the removal of the oil from the lower ring-groove around the space behind the ring. This hole, which is drilled diametrically opposite the longitudinal groove, permits the oil to travel around each half of the circumference of the piston in the space back of the piston-ring to its point of removal. Many factory tests were run in an endeavor to remove the oil completely from the piston-ring groove before the idea was conceived of drilling this small but very important hole. Without it we encountered the same trouble that is sometimes experienced in driving a motor car when the cap of the gasoline tank is made air-tight, thereby creating a vacuum in the fuel tank which would tend to offset the vacuum set up by the engine. In other words, this small hole serves as a vent to break the vacuum when it is applied to the groove and prevents the setting-up of pressure equilibrium that would hinder the flow of gas and oil. Thus this small hole, *E*, makes it possible to remove completely and more efficiently hot gases or condensed fuel along with the lubricating oil from the ring-groove. The hot gases or air tend to aerate the oil when it is in the trap or upper part of the device.

At the lower edge of the piston, and in direct register with the hole *A*, is a narrow vertical extension, *F*, that prevents the hole in the cylinder wall from being uncovered when the piston is traversing the upper part of

the stroke. In some engines, due to the small bore, the long stroke and the shortness of the connecting-rods, it is necessary to place the hole *A* and the piston extension *F* slightly off-center, to prevent the connecting-rod from striking this extension. In practically all cases, however, it is possible to place the extension *F* and the hole *A* 90 deg. from the wristpin.

HOW DILUTED OIL IS SUBJECTED TO HEAT

The oil, hot vapors and unburned fuel withdrawn from the piston-ring groove enter the top compartment of the device at the center casting *G*. This top compartment is surrounded by a heater that is either cast integrally with the exhaust-manifold or attached to it, so that a portion of the hot exhaust gases is caused to pass around this compartment, thereby supplying the necessary heat to drive out the contaminations. This center casting *G* has attached to it a large baffle, *H*. The purpose of this baffle is to cause the oil to pass between it and the outside shell of the device so that it can be subjected to the exhaust heat during the time the engine is warming-up or when it is first started. It is also necessary to have the oil subjected to this heat during practically the entire time the engine is in operation in extremely cold weather.

During the time the oil is subjected to this exhaust-heat, it also has the hot vapors or gases that are removed from the lower piston-ring groove passed through it. This vapor passing through the oil aerates it and distills off the volatile constituents at a very low temperature. Very many tests were necessary to convince us that it was possible to keep the dilution under 10 per cent without subjecting the oil to a temperature of more than 150 deg. fahr. Since the oil is under fairly high vacuum from the time it is removed from the ring-groove of the piston until it returns to the crankcase, it can readily be appreciated that the distillation can be accomplished at much lower temperatures than if this process were followed at atmospheric pressures.

The contaminations or diluents of the oil which are refined or volatilized are drawn by the intake vacuum

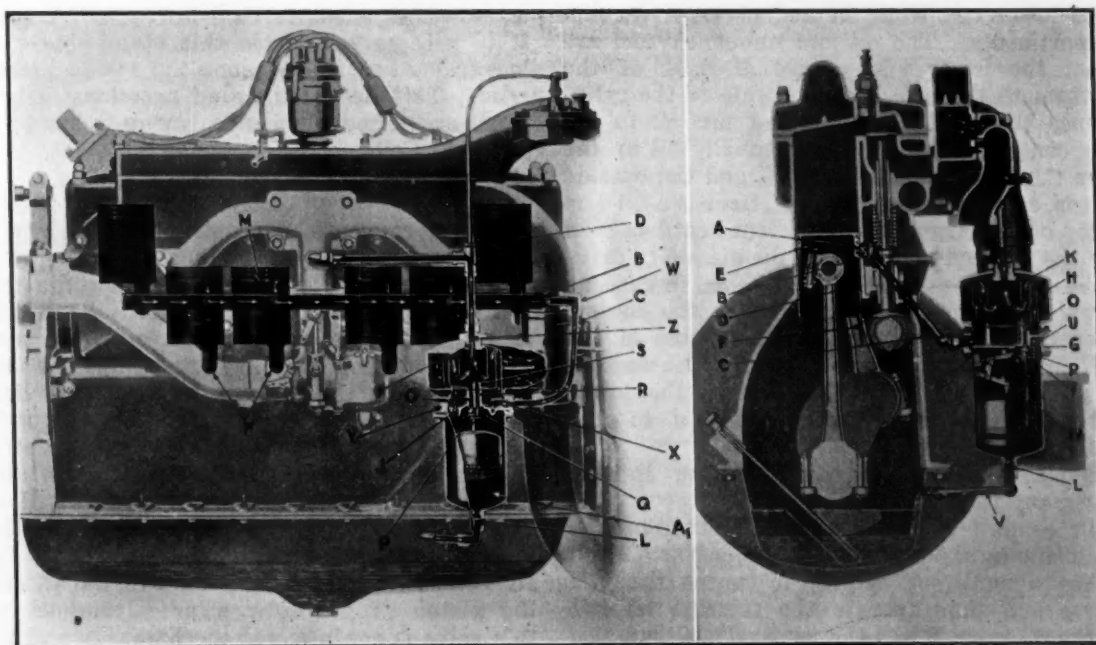


FIG. 4—THE SYSTEM NOW IN USE

By Using a Piece of Thermostatic Metal To Open a Small Valve Automatically at a Predetermined Temperature the Oil That Was Removed from the Piston Would Not Be Subjected to an Excessive Amount of Heat. In This Way the Carbonizing Problem Was Solved and It Is Possible To Keep the Dilution Down to Any Desired Percentage and the Viscosity of the Oil Does Not Increase

through the top connection *I*, back into the intake-manifold of the engine, where they are again used for fuel. This hot vapor or gas that enters the intake-manifold seems to help break-up the carbureter mixture and not only increases the fuel mileage appreciably but makes a better-running engine and materially reduces the amount of heat necessary to be applied externally to the incoming engine gases.

THE FUNCTION OF THE THERMOSTATIC VALVE

As soon as the oil in the space between the large baffle *H* and the outside shell of the device reaches a predetermined temperature, the small thermostatic valve *J* opens automatically, allowing all the oil accumulated in this space to flow to the lower compartment of the device without being subjected to excessive heat and aeration. A small inside baffle, *K*, is located in the top compartment of the device. The two baffles assist in eliminating from the gas any of the oil that might possibly find its way into the intake-manifold. For that reason the hot vapors are caused to pass by and around these sharp corners, so that the oil contents will be precipitated into the bottom of the large baffle *H*. The refined oil passes into the lower compartment of the device and is intermittently and automatically delivered by a float mechanism to the crankcase of the engine.

In order that the operation and construction of the device may be more clearly understood, it is shown in greater detail in Fig. 5. It will be noted that the top compartment is under vacuum from the intake-manifold during the entire time the engine is in operation. This makes it possible to maintain a vacuum against the piston at the hole *A*, Fig. 4, 100 per cent of the time. In the lower compartment the vacuum is intermittent, depending on the number of times the mechanism is caused to operate.

FOLLOWING THROUGH THE OPERATION OF THE SYSTEM

Immediately the engine is started, vacuum is produced in the intake-manifold which is connected with the upper and lower compartments of the device. This causes the ball valve *L* to move upward against its seat in the bottom of the lower compartment and places a vacuum on both compartments. The oil and unburned fuel are removed from the lower ring-groove *M* back of the piston-ring, through the hole *A* in the side of the cylinder, and thence through the connecting pipe *C* to the hole *N* in the center casting *G*, and gradually fill up the space between the large outside baffle *H*, and the outside shell of the top compartment. By the time the oil has reached the top of the large baffle, sufficient heat has been generated by the exhaust-manifold of the engine to drive out the volatile constituents of the oil. These, in gaseous form, are drawn into the intake-manifold of the engine. The separated oil is precipitated to the bottom of the large baffle *H*, passes through the connecting passage *O* and thence goes through the valve *P* into the lower compartment of the device, causing the float to rise gradually in this compartment.

The air displaced by the oil accumulating in this lower compartment passes by the valve *Q*, through the passageway or conduit *R*, up through the stand-pipe *S* and thence into the intake-manifold of the engine. When the oil reaches a sufficient height, it causes the two springs to trip and thus operate the fulcrum lever *I* which closes the oil valve *P* and the vent-valve *Q* and also opens the air relief-valve *U*. The closing of the two valves *P* and *Q* disconnects the vacuum from the lower compartment. The opening of the relief-valve *U* permits

the lower compartment to be under atmospheric pressure. The weight of the oil then opens the ball-valve *L*, allowing the accumulated oil to pass through the pipe *V* into the crankcase of the engine. As soon as the oil drains down to the proper level, the float causes the valve-actuating lever *T* to open the air exhaust-valve *Q* and close the air relief-valve *U*. When the vacuum is again equal in both compartments, the oil-valve *P* drops by its own weight and the accumulated oil again passes through the duct or passageway into the lower compartment.

FUNCTIONS OF THE FLOAT-OPERATED VALVES

The float and valve-operating mechanisms are similar to the ones used in a vacuum tank for fuel systems, except that an additional valve, *a*, Fig. 5, is placed between the upper and lower compartments. This large oil-valve *a* is closed mechanically but it is caused to open automatically by its own weight. The reason for using these two valves may not be perfectly clear without explanation. It was found that so much oil was removed from the pistons that it was impossible to cause it to flow through a single-valve opening from the top separating compartment into the lower compartment. The problem is similar to that of endeavoring to fill a bottle without some means of allowing the air displaced by the liquid to flow out. Therefore we have provided a small mechanically operated valve, *b*, that connects with a small stand-pipe, *c*, located inside the large baffle. As the top of this stand-pipe is above the level of the oil, the displaced air can pass from the lower compartment without interfering with the downward passage of the separated oil through the oil-valve *a*. The small stand-pipe *c* also allows the first rush of air that comes immediately upon opening the valves *a* and *b* to pass through the oil accumulated inside the baffle *d* without forcing a small drop of it to bubble and be drawn out through the top connection *e* into the intake-manifold.

As it requires only about from 4 to 7 sec. for the oil in the lower compartment to drain out, we have found that a projection $\frac{3}{8}$ in. in height is sufficient under all practical conditions. Under extreme conditions, where an excessive amount of oil is removed from the pistons, it is necessary to have this stand-pipe *c* considerably longer. When this is done the inside baffle *f* is shortened. This has been found necessary only in very extreme cases, and when endeavoring to handle an abnormal amount of oil.

HOW THERMOSTATIC VALVE CONTROLS HEAT APPLICATION

The thermostatically controlled valve *g* is of the floating type, positively closed when the thermostat is cold, but opens by its own weight when the metal tension is released. It is closed automatically when the device is emptying the accumulated oil into the crankcase. This is accomplished by trapping the rush of air occasioned by the opening of the air relief-valve *i* in the jacket, *h*, surrounding the valve, thus causing the valve to lift against its seat. When the air relief-valve *U*, Fig. 4, is closed, this valve *g*, Fig. 5, then opens by its own weight. It is possible to adjust the thermostat by the screw, *j*. It is readily seen that, when once adjusted, it will maintain the proper opening indefinitely. Just as soon as the temperature of the oil removed from the piston drops below a predetermined temperature, this valve is again closed mechanically and the oil starts to accumulate in the space between the outer shell and the large baffle. It has been found by actual tests made in fairly cool weather that this valve is closed very

frequently by the thermostatic metal, due to the temperature changes encountered in ordinary driving.

A coiled spring will be noted entirely surrounding the bottom of the float. This spring acts as a float-guide and at the same time allows the oil to pass by it without any restriction. Due to the number of points of contact of this spring against the wall of the lower compartment, and the further fact that it operates in oil continuously, no wear has ever been encountered, even under most extreme and extraordinary conditions. By placing the guide in this position, it is also possible to make the device much shorter and more compact.

TEMPERATURES IN THE SYSTEM

For the benefit of those who may be interested in the degrees of temperature encountered in the various parts of the system, thermometer readings at various points have been taken. At point *W*, Fig. 4, which is in the busbar as close as it is possible to place a thermometer to the cylinder wall, the temperature is naturally substantially the same as that of the atmosphere when the engine starts. But when the engine is operated for a considerable length of time under extreme conditions, this temperature increases to a maximum of 180 deg. fahr. It is, of course, governed by the cylinder-wall and piston temperatures. The normal temperature is from 135 to 150 deg. fahr.

At the entrance to the top compartment, at *X*, there is a drop of approximately 10 deg. fahr., depending entirely upon the length of the connection between the busbar and the device. At *V*, which is diametrically opposite the point where the oil enters the top compartment, the maximum temperature has reached 255 deg. fahr. on very many occasions when the car speed has been 55 m.p.h. At the top of the device, a thermometer placed at *Z*, directly in the path of the gases as they left the device, has registered as high as 500 deg. fahr. on numerous occasions, under extreme speed or conditions similar to those just mentioned.

The normal temperature of the vapors coming out of the device at a car-speed of 35 m.p.h. is from 235 to 250 deg. fahr. This makes evident the amount of heat that the oil would be subjected to if the little thermostatic bypass valve *J* were not used.

The temperature of the oil in the bottom compartment of the device at *A* is normally about from 100 to 125 deg. fahr. There are, of course, extreme conditions when it will rise to 160 deg. fahr., but, as this compartment is cooled by the fan-blast and the natural draft occasioned by the moving vehicle, it is at approximately the same temperature as the crankcase oil.

THE AMOUNT OF OIL HANDLED BY THE DEVICE

The amount of oil normally removed from the pistons, and passing through the device, varies entirely with the clearance of the pistons and the methods used in lubricating the wristpins. Some engines use connecting-rods fitted with oil-tubes to force an abnormal amount of oil up to the wristpin bearings. Other engines depend entirely on the oil thrown on to the cylinder wall and the piston surfaces by the revolving crank-throws. This condition changes according to the amount of clearance in the various bearings. It has been found on a conventional eight-cylinder V-type engine that 1 qt. of oil is handled every 5 to 7 miles at an ordinary touring speed, with 0.0025 to 0.0030-in. clearance. A straight eight-cylinder engine with piped rods handled 1 qt. of oil every 2 miles. This is an unusual condition, but it

is cited to show the capacity of the system. The float trips the valves approximately six times for each quart of oil handled. The average amount removed is 1 qt. every 5 to 12 miles. Since all the moving parts of the device run continuously in oil, a very small amount of wear is encountered.

As the amount of vacuum available for use is governed entirely by the throttle openings, it is apparent that at high speeds, or when quick acceleration is taking place, only a small amount of suction can be applied to the sides of the pistons because of the drop in the intake

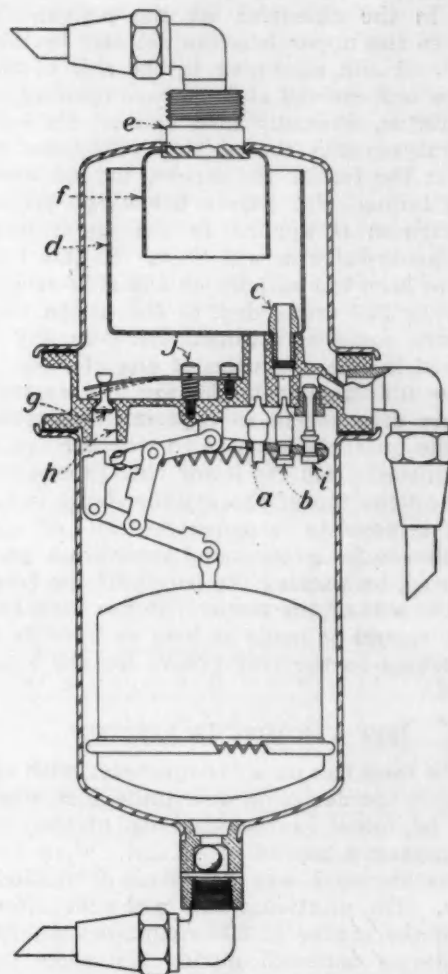


FIG. 5—DETAILS OF THE DEVICE

In General the Float and the Valve-Operating Mechanisms Are Similar to Those Used in a Vacuum Tank. The Coiled Spring Surrounding the Bottom of the Float Acts as a Guide and at the Same Time Allows the Oil To Pass by It Without Any Restriction. This Gives a More Compact Device and, Due to the Number of Points of Contact of the Spring against the Wall of the Lower Compartment and Also to the Fact That It Operates in Oil Continuously, Wear Is Eliminated.

vacuum. When the engine is coasting or throttling, the vacuum pressure on the piston varies from 17 to 23 in. of mercury.

Experiments have been conducted on engines using a separate means for creating an abnormal amount of vacuum by a vacuum pump. An engine was operated at 3000 r.p.m., full load, in an endeavor to learn whether it is possible to remove enough oil from the pistons so that bad effects could be noted due to a lack of oil. On this test 5 gal. of oil was removed from the side of the piston in 1½ hr. operation of the engine under the said

conditions, the vacuum maintained on the pistons being 22 in. of mercury. After measuring the oil it was returned to the crankcase. This test proved beyond question that it is impossible to remove enough oil from the piston to interfere with the lubrication in any way.

Experiments have also been conducted to determine whether placing the vacuum on the ring-groove substantially 100 per cent of the time would have any effect on the operation of the engine so far as lack of oil is concerned. This was done in the manner illustrated in Fig. 6.

To do this, an additional longitudinal slot, *k*, was machined in the extension on the piston. This was connected to the upper longitudinal slot by means of a bypass, *l*, cast and machined in the side of the piston. This bypass was covered at its bottom opening by a small spring-valve, *m*, normally held against its seat. This arrangement permits the suction to bypass when the piston is at the top of the stroke, but as soon as this lower longitudinal slot passes below the cylinder bore and the vacuum is applied to the upper longitudinal slot, this spring-valve *m* will close. In this manner we were able to keep the vacuum on the ring-groove during approximately 350 crank deg. of the piston travel. No better results could be attained, nor was any improvement noticed in the operation of the engine. As complications would arise from the use of this small valve, it was never used except in experimental work.

Should the question arise as to whether too much oil could be removed from the lower ring-groove and therefore under-oil the top of the cylinder-bore, it is pointed out that it is possible to meter the time of application of the vacuum to the groove, and accordingly the amount of oil removed, by varying the length of the longitudinal groove in the side of the piston. It has been found that this groove should be made as long as possible to maintain the vacuum on the ring-groove for the longest possible period.

HOW VISCOSITY IS AFFECTED

Tests have been run on a dynamometer with an engine equipped with the device to determine just what difference could be found in the viscosity of the oil in the crankcase during a period of 12 hr. With the device attached the viscosity was decreased from 350 to 340 Saybolt sec. The dilution was 5 per cent after 12 hr. operation of the engine at 800 r.p.m., developing 15 hp. With the device detached during the same period of time the viscosity dropped from 350 to 231 Saybolt sec. The dilution was 18 per cent and was continuing to increase. Fig. 7 shows very clearly just what drop occurred. This proves that, even under the most favorable operating conditions, dilution continues to accumulate until it reaches a dangerous point.

In distilling samples of oil to determine the amount of dilution present in the lubricant of engines operated without the device attached, we have found that the first decrease of diluent was noted at temperatures ranging from 190 to 250 deg. fahr. We have run into cases where this temperature was as low as 140 deg. fahr. An average of 50 oil samples showed the first drop in dilution starting at 229 deg. fahr. With the device attached, even in zero weather, the first drop will not come under 350 deg. fahr., and the average temperature that has been found in 50 samples tested was 442 deg. fahr. An average of 50 samples of oil taken from engines not equipped with the device shows the highest dilution to be 92 per cent fuel, and the lowest to be 12 per cent, the average being 43.2 per cent. Fifty samples of oil

taken from engines using the device show the highest dilution to be 12 per cent and the lowest 1 per cent, the average being 6.6 per cent.

The specific gravity of the diluent accumulated with the device attached, when compared with that of the low fractions of the oil used, indicates the viscosity-drop to be very slight. We feel that with the drop in the viscosity being less than 10 per cent, a small amount of dilution is practically of no consequence.

Many things have been accomplished by the use of this system. Numerous tests run on a Ford engine, installed in a Ford car, have proved that if the viscosity of the lubricating oil is kept near its original value, the transmission-band chatter of a Ford, which is so evident with diluted oil, is readily eliminated. The bands last much longer without adjustment, the engine runs much more quietly, and many other advantages result.

By keeping the oil at substantially its original viscosity, so that the "blow" past the piston is reduced to a minimum, water accumulation in the crankcase is eliminated. When the water or moisture is eliminated, corrosion of the various parts is avoided. By keeping the oil from passing by the rings upward into the combustion-chamber, carbon formation is minimized. Tests have been run for many thousands of miles over a period of several years with negligible formation of carbon resulting.

In connection with the various advantages to be secured by the use of a dilution-rectifying system, I will describe tests and give comparative results obtained in a study of the relation of dust and oil contamination to the production of wear on the many moving parts of the engine, particularly the piston-rings and cylinder walls. These tests have been run under extreme conditions and will show that it is the dilution more than the dust contamination which is responsible for accelerating the wear.

DILUTION AND ITS RELATION TO ENGINE WEAR

In the early years of the use of automotive engines, when a highly volatile fuel was available in sufficient quantity fully to meet demands, little complaint was heard about excessive engine-wear in connection with passenger and commercial cars. But it was soon found to be economically advantageous to use a lower grade of fuel in heavy-duty engines, and immediately excessive wear began to appear in tractors, trucks and motorboat engines when distillates and kerosene were used as fuel. This wear was the direct result of the dilution incident to the low grade of fuel used. It was particularly accentuated when heavy dust was encountered under service conditions. It was only natural, therefore, for the manufacturers of tractors and trucks to develop air-cleaners and filters in their efforts to minimize the wear, for wear was commonly attributed to the dust primarily, rather than to the reduction in the viscosity of the oil. Air-cleaners and filters were developed which had substantially a 99-per cent efficiency in removing dust that otherwise would have entered the engine through the intake-manifold and the breather, and while it is appreciated that the use of these devices helps under certain conditions, excessive wear is still very noticeable as soon as the crankcase oil becomes diluted sufficiently to lower appreciably its viscosity.

On the other hand, it has been well known that the wear on such heavy-duty engines, under similar conditions, could be reduced through the use of more volatile fuels. Thus many tractor and truck manufacturers and

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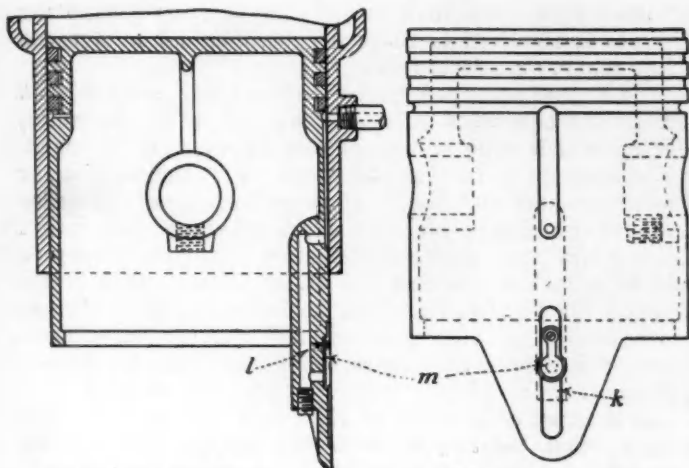


FIG. 6—ARRANGEMENT FOR PLACING THE VACUUM ON THE RING-GROOVES FOR SUBSTANTIALLY THE WHOLE TIME THE ENGINE WAS OPERATING

This Experiment Was Made To Determine What the Effect Would Be on the Operation of the Engine so Far as Lack of Oil Was Concerned. It Was Found That While the Vacuum Could Be Kept on the Ring-Groove for Approximately 350 Deg. of Piston Travel, Better Results Could Not Be Obtained Nor Was Any Improvement Noticed in the Operation of the Engine. The Arrangement Was Therefore Discarded except for Experimental Work

sales agents have recommended the use of gasoline instead of kerosene and distillates in their efforts to enable their products to operate for a longer period of time at the minimum expense. The goal of efficiency which most of them have hoped to attain has been an engine that will perform for 1000 hr. with only minor repairs and 5000 hr. before it is overhauled or rebuilt.

EVIDENCE INDICATES DILUTION, NOT DUST, CAUSES WEAR

This seems to show that the cause of engine wear and the necessity for such frequent recommended changes of the engine oil is not the dust that enters the engine, but the dilution of the oil. If this were not so, no necessity for changing the oil after less miles or hours operated in winter than in summer would exist, for dust is not so prevalent in the winter months. In fact, practically no dust is encountered east of the Rocky Mountains and north of the Mason and Dixon line in winter; yet car-owners are advised to change their oil twice as often during those months as in summer. If dust were the primary factor in producing wear, the reverse would be the course followed.

As further evidence that dilution and not dust is the real cause of excessive wear, we have but to note the fact that, notwithstanding the improvement in road-building during the last 10 years, and the consequent lessening of the quantity of dust encountered on the road, the wear problem has been of increasing seriousness to manufacturers and owners alike. Prior to 1914 crankcase oil was changed only on rare occasions, and in many cases only when the engine was overhauled or the crankcase or pan was removed for bearing adjustments. This was true even though the dust conditions were bad and the carbureter was placed at a low point nearer the road bed. Greater quantities of dust were necessarily drawn into the engines under those conditions than after the development of the vacuum-tank and the higher placement of the carbureters, yet excessive wear was rarely experienced. Why? Because, with the highly volatile fuel, dilution of the crankcase oil did not occur and the viscosity of the oil was not destroyed, with the result that the dust which was not burned up in the combustion process of the engine was prevented by the viscosity of the oil from having any cutting effect upon the engine parts.

This is equally true today. If dilution of the crankcase oil is successfully prevented despite the higher end-point of the available fuel, and the viscosity of the oil is kept up to standard, engine wear will be reduced to the minimum. On the other hand, if dilution is permitted, engine wear will be accelerated even though the engine be maintained in a dust-free condition.

TRACTION-ENGINE WEAR REDUCED BY OIL RECTIFIER

The truth of the foregoing statements is illustrated by two tests. The first test was conducted in California on a 65-hp. tractor using motor distillate for fuel. Prior to the installation of a rectifying device, dilution was so rapid that after the tractor had been run 5 hr. the crankcase, which held 8 gal. of oil at the proper level, had to be drained of 2 gal. to reduce the oil to the required level. After repeating this three times, the customary practice was to drain the crankcase and put in a new supply of oil. No oil was added to the supply between changes. Under these conditions, even during the months of November, December and January, when the minimum amount of dust was encountered, it was necessary to tighten the connecting-rod bearings at least once each week. The wear on the piston-rings and the grooves was so great that new rings had to be put in

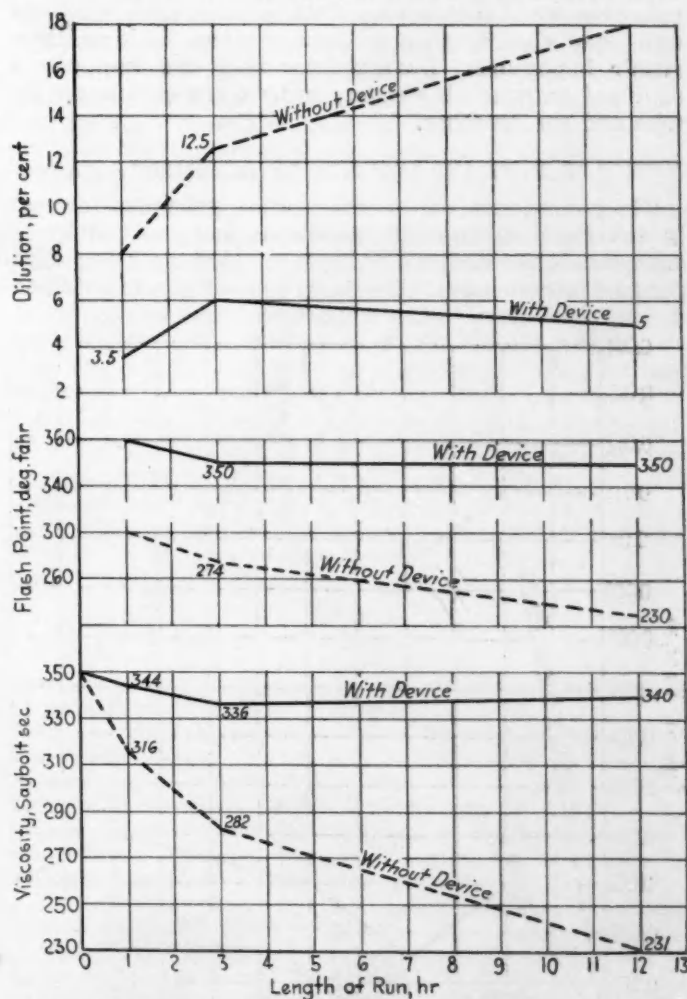


FIG. 7—RESULTS OF TESTS MADE TO DETERMINE THE EFFECT OF KEEPING THE VACUUM ON THE RING-GROOVE OF AN ENGINE

These Tests Were Run on a Dynamometer and the Change in the Viscosity of the Oil in the Crankcase Was Recorded for 12 Hr. It Will Be Noticed That with the Device Attached the Viscosity Dropped from 350 to 340 Saybolt Sec., while without the Device the Drop Was to 231 Saybolt Sec. The Dilution with the Device Was Only 5 Per Cent after 12-Hr. Operation with the Engine Developing 15 Hp. at 800 R.P.M. With the Device Removed the Dilution Continuously Increased to 18 Per Cent in the Same Time

the engine within 60 days, even though it was new when the test started.

The device was installed on this tractor on Feb. 1, without change of pistons, rings or any engine parts, and the tractor was thereafter operated under exactly the same conditions. Instead of drawing off oil from the crankcase, however, it was necessary to add 2 qt. every 10 hr. The tractor was run 200 hr. in plowing and then 150 hr. in harrowing, which is about as bad a dust condition as could be encountered; or a total of 350 operating hr., without changing the oil. The connecting-rod bearings required no attention during this period; they were examined very often during the first few days. They were tightened at the end of the time specified above. The tractor was next used to pull a harvester for 55 days, operating most of the time from 12 to 14 hr. under the worst possible dust conditions. During this period the oil was changed twice.

Thus, after the installation of the device, and the consequent reduction in the dilution even with motor distillate, the tractor was operated more than 900 hr. During the entire period no adjusting of the main bearings was required. This tractor has been operating now for over 3 years, during which time the crankshaft has never been removed from the engine for grinding. The cylinders were replaced in 1922, due to an unexpected cold snap that froze and cracked them, making their repair impossible. During these tests the engine was equipped with an air-cleaner, on both the carbureter intake and the breather.

EFFECT OF DUST AND DILUTION ON AUTOMOBILE ENGINE

The second test was a comparative dynamometer test in the East on two automobile engines, one equipped with the device and one without it, gasoline being used for fuel in both cases. The engine speed was maintained

at 2000 r.p.m., the load being $12\frac{1}{2}$ hp., approximating the power required to drive a passenger car at a speed of 40 m.p.h. on a level road.

The engine equipped with the device was operated 250 hr., or the equivalent of a distance run of 10,000 miles, during which time the crankcase oil was not changed, and but 30 qt. of oil was consumed. The engine without the device was run the same length of time and miles and the crankcase oil was changed every 500 miles. During the time between oil-changes it was necessary to add 30 qt. of oil, so that 130 qt. of oil was used in all. Every hour during the entire operation of both engines a teaspoonful of dust was injected into the carbureter. The comparative-wear results from these tests are shown in Fig. 8.

An average oil-mileage of 1288 miles per gal. was obtained from the engine with the device, against 308 from the one without the device. Bearing trouble was encountered on three occasions with the engine without the device, whereas the engine with the device was run throughout the test without an adjustment or repair, save the replacement of a cracked porcelain in a spark-plug.

These tests were probably the most severe that any engine could be subjected to, but the results with the engine equipped with the device demonstrated beyond all question that dust, as encountered in the ordinary operation of engines, has little wearing-effect upon the engines if the dilution is prevented and the viscosity of the oil is thereby maintained. That viscosity is maintained if dilution is prevented is established by this test. The viscosity of the oil, between the time when it was put into the engine equipped with the device and the time of the conclusion of the test, decreased only from 375 to 360 Saybolt sec.

THE SIZE OF DUST PARTICLES

Very many engineers agree that wear due to dust and grit could be reduced very materially if it were possible to maintain the oil-film between the moving parts of the engine so that the bearing pressures would be exerted on the oil-film instead of on the small particles of dust or grit. As very little is known of the thickness or size of the particles of dust, grit and carbon in the crankcase oil, two samples of used oil were secured from tractors in California, where the dust problem is far greater than elsewhere, and one sample from an automobile engine operating on the streets of Detroit, and these were examined under the microscope. Typical microphotographs are shown in Fig. 10. To facilitate comparison of the sizes of the dust particles, scale-lines 0.0002 in. apart are shown on the photograph, which is magnified approximately 80 diameters. It is evident that the largest of the particles, particularly the carbon particles, is under 0.001 in. in size. Those particles that I believe are dust or dirt are all under 0.0001 in. and some of them are so small as to be hardly discernible. These samples show that more carbon than road-dust is present in the oil. It is also evident that, if the oil-film be maintained at a thickness of over 0.001 in., the dust and dirt will not act as an abrasive, but will be supported in the oil-film. It is apparent that as soon as the oil-film is broken-down by thinning so that its thickness becomes approximately the same as or less than the diameter of the small particles of dust, dirt and carbon, excessive wear will take place.

The Bureau of Standards, in cooperation with the American Petroleum Institute, the Society of Automotive Engineers and the National Automobile Chamber of

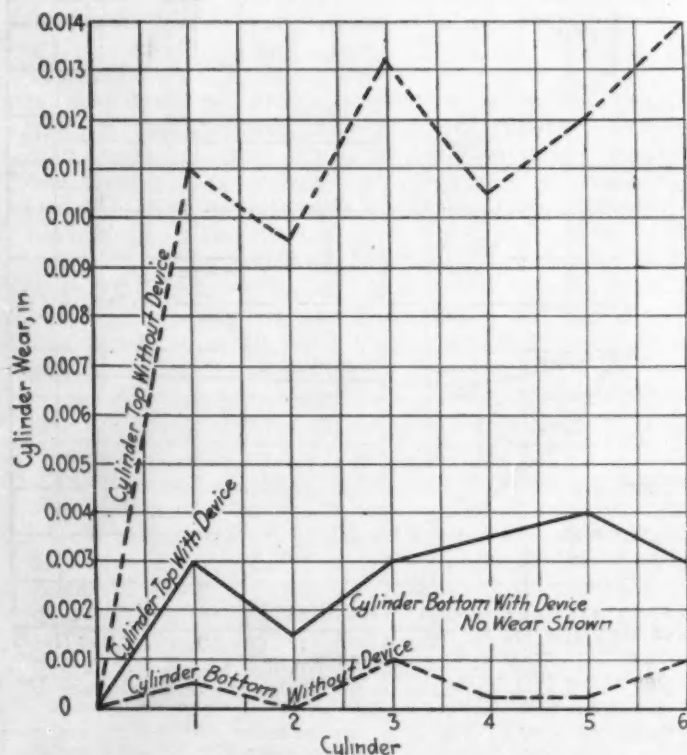


FIG. 8—RESULTS OF TESTS MADE TO DETERMINE THE RELATION BETWEEN DILUTION AND CYLINDER WEAR

The Marked Difference between the Wear of Cylinders on an Engine Equipped with the Dilution-Prevention Device and Those on Another Not So Equipped Is Strikingly Brought Out by These Curves

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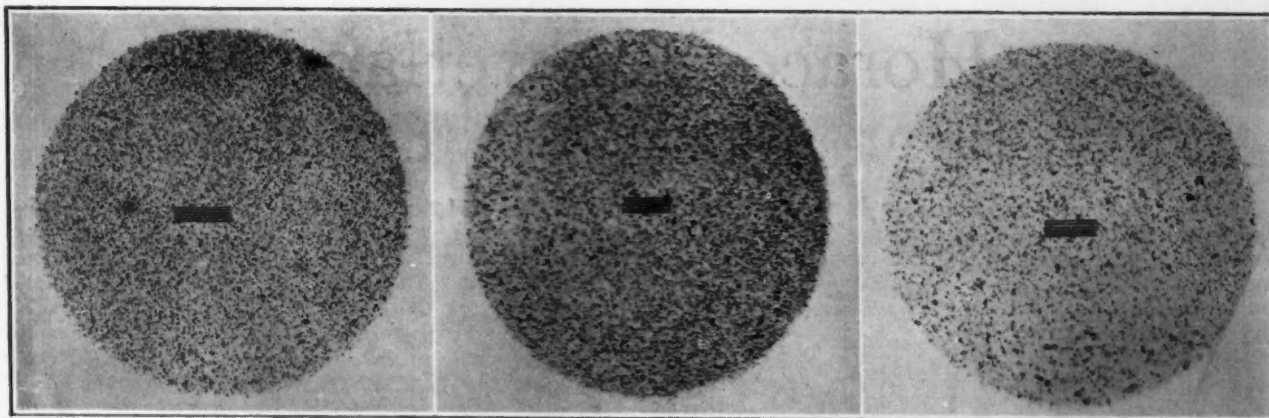


FIG. 9—PHOTOGRAPHS SHOWING THE SIZE OF DUST, GRIT AND CARBON PARTICLES FOUND IN THE CRANKCASE OIL OF THREE ENGINES From Left to Right the Engines Are a 40-Hp. Tractor and a 60-Hp. Tractor Operating in California where the Dust Problem Is Very Acute and an Automobile Operating on the Streets of Detroit. The Space between the Black Lines Indicates, 0.0002 In. in Each Case. The Magnification of the Dust Particles Is Approximately 80 Diameters

Commerce, has conducted tests which have shown that a grade of fuel known as *D*, having an end-point of 468 deg. fahr., can be used in conventional engines if crankcase-oil dilution be prevented. As an economic factor, it is easy to realize the great advantage that would result from the use of this fuel. Seven of the large gasoline producers have estimated that 30 per cent more gasoline of *D* quality can be produced out of the crude than is obtained of the present grade of commercial gasoline. This would place at the disposal of the users of internal-combustion engines many billions of gallons of cheaper fuel, and a consequent decrease in the operating cost per car-mile. A gallon of low-grade distillate contains more heat units than the same quantity of highly volatile gasoline.

RECTIFIER PERMITS USE OF LESS VOLATILE FUELS

Cars equipped with a dilution-rectifying device have been operated successfully with a maximum of 11-per cent dilution during the months of January, February and March in Detroit, using a fuel that consisted of 75 per cent of ordinary commercial gasoline and 25 per cent of Fort-nite oil having an end-point of 480 deg. fahr. This is even lower in volatility than fuel *D*. Engines equipped with the device have been driven thousands of

miles on straight kerosene without an additional heating-device and without a great amount of crankcase-oil dilution. Gasoline was used only to start the engines. It has also been demonstrated that cars can be run many thousands of miles without changing the oil in the crankcase. In some cases cars have been operated over 30,000 miles without changing the oil, and a great many instances of over 10,000 miles of operation can be cited, even during winter weather, the cars being handled by average car-drivers, without the dilution exceeding 11 per cent and without any water present in the crankcase.

The use of a thinner or lighter grade of oil will not only decrease the problems of the automotive engineers, but will increase fuel mileage appreciably, especially in cold weather when cold, heavy oil introduces an appreciable mechanical loss of engine power. At present, however, car manufacturers usually recommend that a heavier grade of oil be used in the winter months, or that the oil be changed more frequently, in their endeavors to overcome the disastrous effects of dilution.

The average user is beginning to consider the length of life of his car, and as soon as he appreciates that it is possible to secure maximum life with minimum wear-and-tear and trouble, he will demand the installation of some form of apparatus that will accomplish it.

TRAFFIC CONTROL

PERHAPS less regulation of street traffic, rather than more, would be advantageous, as proved in the case of an important intersection in the City of Washington, once badly congested. The policeman fell sick and nobody was available to replace him. The traffic promptly cleared itself. He has been replaced by some well-placed permanent guide curbs in the street. It seems especially unfortunate that the use of the fixed synchronous block-signals should be suggested for use in various cities because these have helped in Fifth Avenue, New York City, where conditions are unique. The installation of such an elaborate signal-system should not be made until comprehensive traffic surveys and time studies have been made to determine the characteristics and needs. Then the system should be designed to meet those needs and not for conditions in some distant city. Too much effort has been expended in the

past on "verboden" regulations and too little upon studies of fundamental corrective measures.

Every main thoroughfare has a different character, use and traffic demand factor and requires special design at various points. Especially is this true on street-railway thoroughfares where surface loading stations have become almost imperative, not only to speed up car loading and reduce street accidents, but also to keep traffic moving in streams instead of blocks.

Concentrated transportation means high land values, higher buildings, traffic congestion, then more transportation, and the vicious circle is retraced until the ultimate of congestion, stagnation, is reached. Shall we develop our cities along this unscientific method or set to work to devise a scientific plan of transportation based upon facts?—J. R. Bibbins.



Horace M. Swetland

Founder Member Mourned by the Industry

THE passing of Horace M. Swetland on June 15 came as a great shock to the members of the Society and the automotive industry generally. Mr. Swetland had served continuously for many years as the Chairman of the Finance Committee of the Society. His advice and assistance in this capacity were of the greatest value. He also served as a member of the Council. During the many years of its activity there never was a time when he was not ready and most willing to give the Society the benefit of his long experience and unusual ability. A man of remarkable insight and great business acumen, it is natural that he should have been engaged in large affairs. His success in publication in the automotive field redounded to the benefit of the industry. He was president of the United Publishers Corporation and of its subsidiary, the Class Journal Co.

Mr. Swetland was born in Erie County, Pa., Nov. 15, 1853. In the following year his parents moved to western New York, where he resided until 1881. He was a village school-teacher for 10 years.

In 1884 he became interested in, and a few years later was the proprietor of, the steam-engineering periodical *Power*, which he published until the time of its sale to John Hill in 1902. Thereupon he entered the publishing field of the automotive industry. He inaugurated the issuance of *The Automobile*, now *Automotive Industries*, and promoted *Motor Age*, *Motor World*, *The Commercial Vehicle* and other publications in the automotive field.

He foresaw at an early date the necessity for cooperation among the engineers in the automotive field. In this connection he wrote several years ago in a brief historical sketch of the Society:

Discussions culminated during the 1904 New York Automobile Show in a decision to form a society of engineers engaged in the design and construction of automobiles. Those present at the conference were E. T. Birdsall, A. H. Whiting and H. M. Swetland.

An informal organization was effected at that time by naming A. L. Riker as president and E. T. Birdsall as secretary and treasurer, and appointing Messrs. Whiting, Birdsall and Swetland a committee to draft a constitution. This committee decided on the name "Society of Automobile Engineers," and presented a constitution that provided for membership in the Society, annual dues, the regular officers and a Board of Managers. Under this constitution, in January, 1905, A. L. Riker was elected president; Henry Ford, first vice-president; John Wilkinson, second vice-president; and E. T. Birdsall, secretary-treasurer. In addition the following managers were named: A. H. Whiting, L. T. Gibbs, H. M. Swetland, H. P. Maxim, H. W. Alden and H. Vanderbeek.

It is said that there is no better type of man than the man who can be depended upon under any and all sorts of conditions to fall in and do his level best. That Mr. Swetland was that type of man was well borne out by his attitude toward the Society. For him zest was the chief reward of work. His good humor was unflinching. He was a strong partisan of the policy of live and let live.

Mr. Swetland was a keen motorist. He was a well qualified critic of car performance and himself drove many thousands of miles each year. Of the automobiles of the early days, he said that, while he did not claim to be an engineer, it took more ability to drive the machines than to design them.

In the book entitled *Industrial Publishing*, which he pro-

duced, Mr. Swetland quoted in its concluding passage Napoleon's saying, "Get your principles right. The rest is a matter of detail." This indicates in an illuminating way his view of life. He was "wise enough to understand, broad enough to weigh the evidence, firm enough to follow his own judgment and strong enough to make sacrifices exacted."

Mr. Swetland produced another book entitled *American Journalists in Europe*. This was an account of a visit made in 1918 by industrial journalists of this Country to England and France, as guests of the British Ministry of Information. It gives an unusually graphic description of conditions abroad during the World War. In this book he said:

The principles of democracy are permeating every form of government. "By the people and for the people" must be the basis of intelligent government, whether it be republic or monarchy in form. The welfare of all the people of a nation must have first consideration. Class legislation and eventually politics must be replaced by pure regulations and progressive statesmanship. Capital and labor must unite on a common constructive policy. The division of profits must cease to be the dominant contention. Increased production must have first consideration. Instead of curtailing its efficiency and penalizing production, labor must encourage industry and expect reward proportional to individual effort. Capital must take the intelligent worker into his confidence and give him a voice in the problem of production. Capital must be alert to recognize the intelligent progress of production, and keen to share increased profits with her partner. Civilization today demands less accumulation to capital and less poverty to labor, based, however, in either case on the integrity and intelligence of the productive effort.

The time when the business man cherished secrets, and carefully secluded and jealously guarded his process of production has passed. Cooperation has avoided the wastes of competition, and efficiency has been increased by the more confidential relation between employer and employee. A nation is nothing less than a business organization. Its prime obligation is to so organize and relate its productive capacity as to insure to each individual a proper return for his effort. As the individual business enterprises have learned from experience the benefits of unselfish cooperation, so the nations of the world are beginning to realize that industrial progress depends upon international cooperation. Their commercial rivalry in the world market must be as fair and open as the competition in the home market, and the same principles must be adopted to secure national efficiency as are employed by the individual.

A new epoch is opening in the industrial history of the world, in which a better understanding among commercial nations and the desire to do away with national egotism are rapidly growing.

These paragraphs show the broad outlook of the man. Things are only effects. When the thought is trained to look below the surface, everything takes on a different appearance. Character is the result of continued effort.

Of our friend who is gone, be it said, he was sincere, inspiring and

"Faithful unto death."



HORACE M. SWETLAND

WILLIAM T. BURNS

PNEUMONIA claimed another victim on April 3, 1924, causing the death of William T. Burns, engineer in the automobile department of the Timken Roller Bearing Co., Canton, Ohio, and brought sorrow to this member's wife and three children. He had been in this company's employ 8 years and was 36 years of age.

Born July 9, 1887, at Philadelphia, he acquired his technical education in the Drexel Institute from 1903 to 1906, specializing in electrical engineering. Following his early practical work, he was a draftsman on automobile and electrical industrial truck design for the Pennsylvania Railroad Co., Altoona, Pa., until 1913 when he became assistant chief

telephone inspector for this company. In the latter capacity he was in charge of the design of railroad telephone equipment and the development of electrical and mechanical equipment for the psychological testing of trainmen.

Entering the service of the Timken Roller Bearing Co. in 1917, he was first employed in selecting and recommending Timken bearings for tractor usage and later was engaged in bearing design and the recommendation of these bearings for all automotive uses. He was an associate member of the American Institute of Electrical Engineers, and was elected to Member Grade in the Society of Automotive Engineers on March 1, 1920.

RICHARD R. ZIMMER

SAD news is recorded herewith of the death on April 27, 1924, of Richard R. Zimmer, aged 40 years. He was research engineer for the Wright Aeronautical Corporation, Paterson, N. J. Born in 1884, at Strassburg, Alsace-Lorraine, and educated in the Berlin-Charlottenburg Technical High School, he came to the United States following his graduation in 1910 and was naturalized as an American citizen at New Brunswick, N. J., in 1914.

His practical work in this Country began in 1910 with the Crane Motor Car Co., Bayonne, N. J., and he was employed

there as a draftsman on automobile design until 1914. From 1914 to 1920 he was engaged in similar work for the Simplex Automobile Co. and in aeronautical-engine design for the Wright-Martin Co. Becoming chief engineer for the du Pont Motors, Inc., Wilmington, Del., in 1920, he was later in charge of the engineering department of the Lawrance Aero-Engine Corporation, New York City, and subsequently became connected with the Wright Aeronautical Corporation. He was elected to Associate Member grade in the Society on Feb. 24, 1914, and to Member grade on Jan. 10, 1921.

W. De GROFF WILCOX

IN a recent notice from the Edward G. Budd Mfg. Co., Philadelphia, announcement is made of the death on May 24, 1924, of W. De Groff Wilcox, aged 44 years, its Detroit sales engineer. Mr. Wilcox was born, Dec. 1, 1879, at Valparaiso, Ind., and was graduated from the Chicago Manual Training School in 1899. Entering the Pullman Car Works in that year, he was employed there in various capacities at shopwork until 1909, and was a draftsman for this company

from 1912 to 1913. For about 3 years, 1909 to 1912, he was an inspector for Forsythe Bros. Co., Chicago.

In 1913, Mr. Wilcox entered the service of the Edward G. Budd Mfg. Co., in Philadelphia, and in 1916 he was chief inspector for this company; later, he became connected with its Detroit office.

He was elected to Associate Member grade in the Society, Sept. 12, 1916.

GASOLINE TAX

THE proponents of the gasoline tax hold that it is the only form of automobile tax taking into account the three factors of distance travelled, weight and speed of vehicle. Furthermore, they argue, being in the form of a sales tax, it is easily and cheaply collected and is a fair measurement of the amount of money that a vehicle should pay for the use of the roads and the damage thereto. In addition, it forces the tourist from outside one State to pay a fair price for the use of the highways of another State, which he has not helped to build by the payment of registration or license fees.

However, considerable opposition to the gasoline tax as a method of taxing motor vehicles exists. The opponents of the gasoline tax maintain that the extent to which the owner of a motor vehicle may enjoy the benefits of the public highways is in no way related to the amount of tax he pays and that the amount of his tax is not proportional to the extent to which he uses the public highways. They deny that it is the fairest and most equitable measure of road use and that it does not make the persons who destroy the roads pay for them. They deny that the gasoline tax is easily and economically collected and hold that only one tax should be imposed on the motor vehicle and one agency for collecting it. Further-

more, they maintain that the present form of registration fees and method of collection represent all the means that should be used for the collection of all the tax levied against the motor vehicle.

Nevertheless, the gasoline tax has become very popular and its development and adoption as a method of taxing motor vehicles has been very rapid. The first tax of this kind was passed by the State of Oregon in 1919. Since that time, 36 other States have followed that example and passed similar legislation. The indication is that within a few years this form of taxation will have been adopted by every State in the Union. The automotive industry, as represented by the Motor Vehicle Conference Committee, does not object to the gasoline tax, per se, unless it is added to the already existing taxes on the motor vehicle, its chief interest being the amount of the tax, rather than the form. It does object, however, if this is added as an extra tax and becomes a supertax on the operation of motor vehicles. If the other taxes are reduced to the minimum, then a gasoline tax is not objected to so long as the amount of money obtained is no more than enough to maintain the properly located and constructed highways of the State.—H. H. Rice.

Recent Observations of Air-Cleaning Devices

By CHARLES P. GRIMES¹

SEMI-ANNUAL MEETING PAPER

Illustrated with DRAWINGS

THE author summarizes his experiences and conclusions in chronological order, covering the last 3 years, beginning with the time he first started work with air-cleaners. He gives data on 16,000 cleaners produced in the last 2 years. He sets forth all of his reasons and experiences leading up to the recommendation of a centrifugal cleaner. An interesting suggestion on crankcase construction calls attention to the vicious practice of washing all dust collected in the breather down to the oil-pan with each fresh filling of oil.

ATTACHED the first air-cleaner of the type described herein in 1921 and studied its performance while traveling over 1000 miles of dusty roads to the Summer Meeting of the Society at West Baden, Ind. One year later this cleaner was put into production. During the last 2 years 16,000 cleaners have required no service except lubrication to one out of each thousand. This slight attention has been eliminated by the use of adequate felt oil-retainers that are ample for years of hard service. Eighty-nine different manufacturers are using this centrifugal cleaner as standard equipment.

The entire automotive engineering fraternity now look to clean air for increased engine-life. We do not change the lubricant in our transmissions and differentials each 500 or 5000 miles. Why? Because they are sealed dust-tight.

Before getting excited over the problem of crankcase-oil dilution, we should stop to consider the performance of the old reliable two-cycle marine engine that would run for days and days under full load on lubricating oil fed to it in the fuel. This was absolutely satisfactory because the oil was clean; and gave excellent engine-life, fully twice that now obtained by an unprotected automotive engine. Three years of constant study has convinced me that engine life is absolutely dependent upon clean air and clean oil.

On a hot summer day with a room temperature of 112 deg. fahr. I ran an engine for 2 hr. at 1600 r.p.m., full load. During all of the last hour the oil temperature registered from 200 to 230 deg. fahr. I observed that the oil when hot showed slightly less friction and slightly more power than when at a temperature of 100 deg. fahr. The bearings, however, were not affected by this oil because it did not contain dirt, dust or other abrasive material. I have a definite record of a production-car engine that was completely worn-out in 500 miles because a small quantity of sandblast grit had been retained on the interior of the suction yoke during the process of cleaning and plating. Unprotected from dust, tractor engines have often been ruined in 48 hr.

TYPES OF AIR-CLEANER

To my knowledge, there are five types of air-cleaner. I found the sea-weed and oil cleaner to be efficient, very bulky, but disagreeable to service.

The water-trapping cleaner depends for its performance upon the joints, valves and mechanism that control it, and also upon the fineness of the air bubbles passing through it. I hated to dig out the mud and refill it.

Layers of dust, oil vapor, dirt and moisture have succeeded in clogging the pores of the best cloth-filter I have ever tested to such an extent that the carbureter wasted fuel on account of the increased restriction.

When discussing air-cleaners, we must bear in mind the necessity for maintaining a uniform restriction of the air-flow to the carbureter and distinguish between those cleaners that are constant and those that are variable. I know from years of experience gained through research that any modern carbureter can be adjusted to

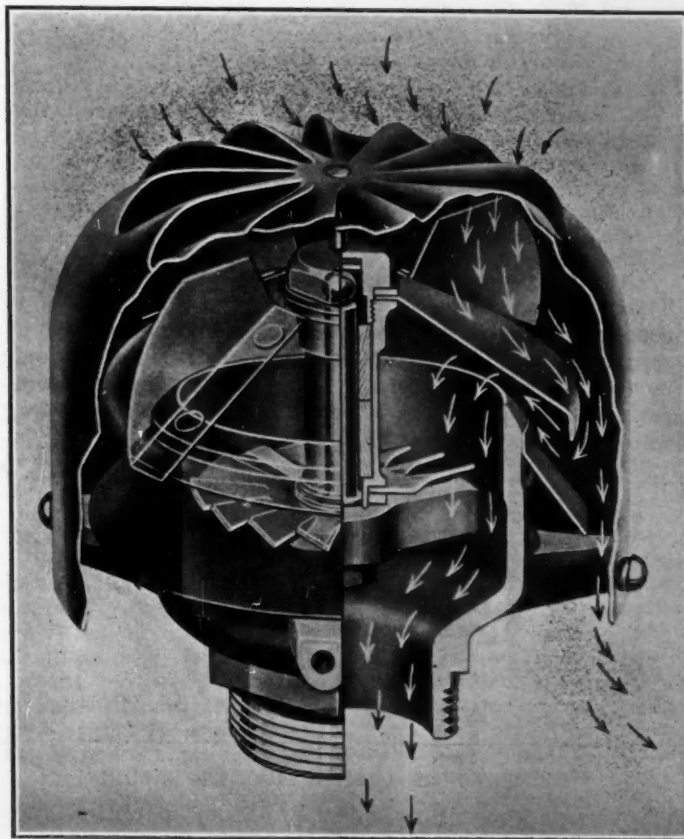


FIG. 1—VIEW SHOWING THE CONSTRUCTION OF A SELF-EJECTING CENTRIFUGAL AIR-CLEANER

Four Fan-Blades Carried on the Upper Rotating Disc Are Driven at High Speed by the Lower Motor-Fan. This Upper Rotating Member Imparts Sufficient Centrifugal Force to All Dust Particles To Carry Them into the Outer One-Quarter-Volume Zone and Also Acts as a Centrifugal Blower To Suck into the Top of the Cleaner Slightly More Air than That Required To Fill the Dust-Laden One-Quarter Volume. This Extra Volume, Along with the Remainder of the Air, Is Compressed Sufficiently at a Point Just under the Edge of the Rotor To Supply All of the Carbureter Air and Also Eject the Surplus One-Quarter Volume with Its Burden of Dust. In Addition the Entire Rotating Member Serves as a "Flywheel" To Smooth-Out Violent Surges in the Carbureter Air-Stream That Are So Common when Full Power Is Being Developed at Low Speed

¹ M.S.A.E.—Syracuse, N. Y.

perform practically perfectly, regardless of the pressure or suction that may be placed on its entering air, provided that this pressure or suction is constant for any given volume of air-flow. I have worked pressures on turbo-boosters up to 7.5 lb. per sq. in. I have worked suction up to 16 in. of water with entire satisfaction.

The inertia type of cleaner depends upon the velocity of air behind a fan for its cleaning efficiency. Rays of sunshine showed the influx of dust to the carburetor to be apparently so great that I abandoned this type as unworthy of further consideration.

SELF-EJECTING CENTRIFUGAL CLEANER

The self-ejecting centrifugal type of cleaner contains but one moving part, made from aluminum stampings mounted to rotate upon a single steel ball-bearing. This bearing is cushioned against mechanical shock by adequate felt pads that act as oil reservoirs, with a retaining capacity of 65 drops of oil, which is ample for 2 years of continuous service. To assure alignment, two oilless wood bushings guide the rotor on the lower part of the vertical steel shaft.

I selected this self-ejecting centrifugal dry air-cleaner in preference to all others because

- (1) Maintenance and service had been reduced to the vanishing-point
- (2) The owner could see it perform at a glance
- (3) The air resistance through the cleaner did not change in 2 years of use. Therefore, the carburetor once adjusted was set for life
- (4) It actually removed 97 per cent of the finest, driest, air-float dust that I have been able to obtain. I do not know that the remaining 3 per cent of this powder dust actually went through the cleaner but, when I weighed up at the finish, the dust was not in my catch-bag and I charged it against the cleaner

Ordinary road-dust cleans better than 99 per cent. The figures in Table 1 present but one logical method of separation, the centrifugal. This is the same force that separates cream from milk and has so far been the only method known to scientists for concentrating and separating the minute oyster-egg from the surrounding water.

TABLE 1—RELATIVE WEIGHTS OF COMMON DUST PARTICLES COMPARED TO AIR

Water	860
Soft Brick	1382
Portland Cement	1066
Very Fine Sand	1238
Loose Earth	1100
Fire Brick	1930
Fine Wheat Flour	546

PRINCIPLE OF CENTRIFUGAL OPERATION

To separate even 99 per cent of all dust particles from the entering air would require an unreasonable expenditure of power at enormous speed. The designer of the self-ejecting centrifugal cleaner shown in Fig. 1 discovered that almost no power at all is required to centrifuge all of the dust particles into the outer-zone which comprises one-quarter of the air volume entering the cleaner. The dust-laden air in this outer-quarter volume is allowed to escape through a proper-sized opening at the lower outer circumference, taking all of the dust particles with it. The remaining or inner-three-quarters volume is perfectly clean and causes the air motor-

fan to rotate while passing through it to the carburetor. This is a very simple process; positive, entirely plausible, and it works to perfection.

The upper rotating disc carries four fan-blades as shown and is driven at high speed by the lower motor-fan.

The upper rotating member performs two distinct functions. It imparts sufficient centrifugal force to all dust particles to carry them into the outer one-quarter-volume zone. It also acts as a centrifugal air-blower to suck into the top of the cleaner slightly more air than that required to fill the dust-laden one-quarter-volume. This extra volume is compressed along with the rest of the air at a point just under the edge of the rotor, this action being sufficient to supply all of the carburetor air and at the same time forcibly eject the surplus one-quarter-volume with its burden of dust.

The entire rotating member also acts as a "flywheel" to the carburetor air-stream. It may pull or push as the occasion demands, to smooth-out those violent surges that are so common at low-speed full-power, to the extent of actually increasing the engine torque as much as 8 per cent, with less fuel as noted in Table 2.

TABLE 2—EFFECT OF THE CENTRIFUGAL-EJECTOR AIR-CLEANER ON TORQUE, FUEL CONSUMPTION AND YOKE SUCTION²

Speed, R.P.M.	Without Cleaner			With Cleaner			Advantages	
	Load, Lb.	Fuel Con- sump- tion, Pt. per Hr.	Yoke Suc- tion, In. of Mer- cury	Load, Lb.	Fuel Con- sump- tion, Pt. per Hr.	Yoke Suc- tion, In. of Mer- cury	Tor- que In- crease, Per Cent	Fuel Con- sump- tion De- crease, Per Cent
200	89.5	8.5	0.10	96.7	7.4	0.10	8.00	12.95
400	102.0	15.5	0.20	107.0	13.9	0.15	4.90	10.31
600	105.5	20.8	0.35	107.2	19.7	0.35	1.60	5.10
800	102.5	25.8	0.45	103.5	23.2	0.55	0.97	10.08
1,200	107.8	36.3	0.85	112.8	34.5	1.00	4.64	4.97
1,600	107.4	46.0	1.35	107.5	45.0	1.50	0.93	2.08
2,000	100.5	54.0	1.80	100.0	51.0	2.10	0.50*	5.55

² These data were obtained in tests of a six-cylinder water-cooled large-production automobile engine and are thoroughly representative of a number of similar tests.

* Loss.

Another very desirable feature of the rotating member is noticeable during the period of acceleration. The inertia of the rotor is sufficient to retard the flow of the carburetor air just enough to allow the gasoline to catch up so that both may reach the combustion-chamber in proper proportions to form a powerful mixture. Having set forth the reliable simplicity of the centrifugal cleaner that I have selected above all others, I must caution engineers that the best results cannot be obtained with the centrifugal cleaner unless the proper size is selected.

The data shown in Table 2 were obtained from the laboratory of a prominent six-cylinder-engine automobile manufacturer. The first run was made under the conditions of its standard production adjustment. The second run was made with the centrifugal air-cleaner attached after one or two trials of gasoline adjustment had been made to compensate for the slight amount of air resistance added by the cleaner. I am prepared to repeat this test at any time.

CLOSING REMARKS

The Society has been and will continue to be the salvation of the automotive industry. It stands unsurpassed as a clearing-house of ideas and experiences. It has

been my endeavor to state to you clearly my experience in connection with the first automobile manufacturer to adopt an air-cleaner as standard equipment on his product.

I have been talking specifically to you on air-cleaners but naturally my study of them has brought me into close contact with dirt and dust particles and the damages caused by them. Before concluding I want to bring before you one other point that it seems to me is very important in connection with crankcase construction. I want to warn you against the common practice of com-

bining the oil-filter and oil-breather on the crankcase.

The crankcase breather is often an enlarged tortuous passage with an oil-screen permanently mounted near the entrance. This passage and the screen must be open to dusty air for breathing. These same passages are always moist with oil vapor which catches all dust particles passing nearby. It really is an excellent dust-filter that should be detached and cleaned often. The prevailing practice, however, is to wash all grit and dirt out of this passage into the crankcase when filling with fresh oil.

AMERICAN THEORY OF INDUSTRY

THE American theory of industry differs in essential ways from that of Europe. The American manufacturer demands durability, but he does not desire his equipment to last forever. He knows that mechanical improvements will be made, so great that he cannot afford indefinitely to use machinery of a lower productivity than that possessed by a competitor whose plant is newer. American machinery is built to earn its own replacement costs and to make a profit, but American industry is not disposed to accept the dictum that perfection has been attained in any line as yet or will be in the near future.

Important factors in the sale of American machinery abroad are the development of the principle of interchangeable parts and of the American service systems. These methods are the direct outgrowth of conditions in the United States. Large-scale production tends inevitably to standardization and ultimately to a high degree of interchangeability. The profitable development of service systems would not be possible except in a very wide market. This the United States has furnished. The development of service systems has been further stimulated by the fact that in this Country the supply of skilled mechanics has always been limited in relation to the demand. Service is an American specialty and it is proving to be one of the most powerful factors in placing American exporters of machinery at an advantage in the international market. This system has been no small factor in the mechanization of agriculture. The service

systems maintained by the automobile makers are in a general way similar to those of the agricultural machinery manufacturers.

The bulk of our manufactures for individual use and for household consumption would be hopelessly expensive when measured in terms of the purchasing power of a European peasant, a Chinese coolie or an Indian ryot. On the other hand, the bulk of our product would not meet the luxury standards of the European capitals before the war and the standards that prevail among the few in some parts of Latin America. The United States can afford to admit these limitations, for the future trade of the world which will be above all worth having will be that of the rich new countries that are developing along the lines of our own growth and whose demands are necessarily similar.

The combined automobile market of the entire world, exclusive of that of the United States and Canada, would not be sufficient for quantity production. The price factor in relation to use is interestingly illustrated by the distribution of motorcycles. Of a total of nearly 900,000 motorcycles, foreign countries are credited with about 700,000 and the United States with a little less than 200,000. The motorcycle approximates the purchasing power of considerable numbers of people in such countries as Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Sweden and the United Kingdom, which alone is credited with 400,000.—*Commerce Monthly*.

BURDEN OF POST-WAR TAXATION

IN 1920 an attempt was made, in connection with the Brussels Conference to estimate the proportion between Government revenue and national income in some of the most important countries of the world. All such figures are based on very rough estimates since the war, since the movement of prices and lack of good statistics of output or income leave a very wide margin for error. The results, however, that are here shown in comparison with the pre-war figures seem roughly to conform to the changed conditions of the various countries mentioned.

PERCENTAGE OF GOVERNMENT TO TOTAL NATIONAL INCOME

Country	Pre-War, Per Cent	1919-1920, Per Cent
United States	2	10
Germany	5	15
Australia	7	8
United Kingdom	8	24
Canada	9	10
France	12	14
Italy	13	14
Japan	22	11

At the present time the United Kingdom is probably paying about 18 per cent of its national income in taxation, France 16 per cent, rising to 20 per cent if M. Poincare's taxation proposals are fully enforced, while Germany's tax

burden has recently been put by the German Finance Minister at from 25 to 27 per cent, exclusive of reparations payments. This last figure, however, cannot be accepted without evidence. It can only have been true at the moment when production dropped to its minimum before Christmas, and the proportion will certainly rise as Germany's output recovers. Moreover, if stabilization continues, it will soon become possible to estimate Germany's national income with some approach to accuracy. But the fact that Dr. Luther put Germany's income at 25,000,000,000 gold marks, which equals, say, 16,000,000,000 at pre-war prices or say, £800,000,000, serves to remind us of the need for caution in accepting comparisons of taxation per head as a guide to the burden of taxation. The individual employer may be as rich or richer than before the war. But the mass of the German nation is immensely poorer and has a greatly reduced taxable capacity. An estimate that can be checked of Germany's national income is an urgent necessity.

The figure for France also serves to modify the easy assumption that because, like all largely agricultural countries, she takes ill to direct taxation, she therefore bears a light taxation. The ratio to average income nearly equals, and will soon exceed, that of the United Kingdom. But it is for by far the greater part paid by indirect taxes.—*Economist* (London.)

Air-Filters

By L. L. DOLLINGER¹

SEMI-ANNUAL MEETING PAPER

NOISE increases with the wearing of the parts of an engine. Hence, the elimination of wear will decrease the noise and the attendant cost of operation. A great quantity of dust and grit is set in motion by the wind and by the wheels of moving vehicles. The effect of this dust and grit, when it is sucked by the fan through the radiator into the region of the carbureter air-intake, is more severe in the city than in the country for the reason that in the city it consists largely of ground-up pavement, coal dust, sand and gravel and cement that have been scattered about the city by trucks. The quantity of this abrasive material inhaled through the carbureter also increases as the traffic increases, for the dust and grit stirred up by one automobile is drawn in by a following one. Changing the oil in the crankcase, while important, is not sufficient, because the damage to the engine has been done before the oil reaches the crankcase. Even when driven over apparently clean pavements, cars are found to be covered with a layer of dust and grit consisting of highly abrasive material. As air enters the cylinder the finer particles of grit adhere to the oil-film of the cylinder wall and work into the grooves; and soon the fouling and the wearing of parts become apparent. After passing through the cylinder the oil reaches the crankcase, makes the oil supply gritty and produces wearing of the bearings. Loose-fitting piston-rings complicate the lubricating problem, for a heavy oil is necessary, and the heavier the oil the more viscous it becomes at the low temperatures that are prevalent in cold weather.

Steam engines run many hours per day for many years without much wear, but the internal-combustion engine must have the cylinders rebored and requires new piston-rings after a few hundred hours of service. Approximately \$100,000,000 is spent annually to replace worn piston-rings and bearings, and more than double this amount is spent for the labor of installing them; worn bearings cause a waste of about 750,000,000 gal. of gasoline annually. Although carbon is usually said to be the cause of leaky valves, a careful study shows that it is not carbon but rather particles of sand and grit, coated with carbon that hold the valves open; carbon itself is soft and extremely fine, like lampblack.

Data recently submitted by E. E. La Schum show that the cost of overhauling an engine is about \$550, or about 40 per cent of the cost of overhauling the entire vehicle. As the need of overhauling is caused by wear, this item could be largely reduced by the use of an efficient air-cleaner. Large particles cause trouble but the finer particles will cause infinitely more trouble.

An effective air-filter must have high efficiency, low resistance and durability, should have small size, neat appearance and few moving parts, and should require little attention. According to the returns on a questionnaire recently sent out by the National Automobile Chamber of Commerce, owners of cars specify long life and uninterrupted performance as the qualities most to be desired. Great progress has been made in increasing the durability and life of other parts of cars but the life of the engine has not kept pace. The use of an efficient air-filter would assist in greatly lengthening its life and in materially reducing the cost of operation.

THE difference between a new quiet and efficient engine and an old noisy and inefficient engine is simply a matter of wear. A worn engine consumes more gasoline and oil, delivers less power and eventually requires expensive repairs. The elimination of wear so far as possible, therefore, directly affects the cost of operating motor equipment.

Most manufacturers of motor vehicles have recognized for some time that road dust, sand and grit, drawn in through the air-intake of the carbureter, cause wear; but many think that occasionally changing the oil that has become gritty in the crankcase is all that is necessary to protect the engine. It is desirable to change the oil frequently, but before the dust and the grit reach the crankcase the greater part of the damage to the engine has been done.

In the first place, there is more dust and grit in the air than is generally believed. Not only the wind, but the wheels of other vehicles, and especially street-cars, moving at high speed, set in motion enormous quantities of road dust. Although less dust is visible in the city than is apparent on the dirt roads of the country, city dust contains a much higher percentage of abrasive matter. Road dust consists mainly of ground-up pavement, with sand and grit blown from the roofs of buildings. An appreciable quantity of coal dust, sand, gravel and cement is scattered over the city by trucks carrying these abrasive materials. As traffic increases, these agents become more destructive. When machines follow one another closely, sand and grit thrown up by the wheels of one machine are drawn through the radiator of the following machine and are sucked by the fan directly into the region of the carbureter air-intake. Since the intake-velocity of air in a carbureter is generally from 50 to 150 ft. per sec., the suction is so great that particles of sand and grit near the air-intake opening are drawn into the engine.

If an automobile with a thoroughly clean engine is driven for but a few hours over what is considered a clean pavement, it will be found, on examination, to be covered with a layer of dust and grit which, if examined under a microscope, will be seen to consist largely of highly abrasive material. It is certain that a quantity of this same material has entered the carbureter and has reached the combustion-chamber.

EFFECT OF ROAD DUST AND GRIT ON THE CYLINDER

Consider the piston of an engine as it moves down on the intake stroke, leaving the cylinder wall coated with a film of oil. The air, charged with dust and grit, enters the cylinder at high velocity and strikes the oil-film on the cylinder wall, to which the finer particles of grit readily adhere. As the piston moves up and down, the gritty oil rapidly wears the cylinder walls and the piston-rings. The grit works into the ring grooves and wears both the grooves and the sides of the rings. The result is badly worn pistons, cylinders and rings, loss of compression, fouled spark-plugs, dilution of oil and loss of power. The damage does not stop with the cylinders and the pistons, but the grit works down past the rings, getting into the crankcase and making the entire oil

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supply gritty. The gritty oil causes excessive wear on main bearings, connecting-rod bearings, wristpins, camshaft bearings and especially the cams. When a cam is worn it does not open the valve on time, does not open it sufficiently and closes it too soon, thereby preventing the exhaust gases from being completely expelled.

Loose-fitting pistons and rings complicate the lubricating problem, especially in cold weather. A heavy oil is required to seal the piston-rings, and the heavier the oil the more viscous it becomes when cold. Starting the engine is made difficult and, in many cases, wristpins and bearings are burned before the oil becomes sufficiently mobile to flow to the more closely fitting parts.

Comparing the performance of steam engines with that of internal-combustion engines, it is observed that the former operate several hours a day for many years without much wear on the cylinders or the pistons, while the latter require reboring of the cylinders, new pistons and rings and other repairs after a few hundred hours of service. It is also known that internal-combustion marine engines, which operate more nearly at full-load, show considerably less wear and require less frequent overhauling than do motor-vehicle engines.

It has been shown that approximately \$100,000,000 is spent annually to replace worn piston-rings and bearings, and more than double this amount for the labor of installing these parts. It is estimated that 15 per cent of the more than 5,000,000,000 gal. of gasoline consumed annually is wasted by reason of worn cylinders, pistons and piston-rings. Leaky valves and excessive carbon-deposits are also contributing factors.

GRIT NOT CARBON CAUSES LEAKY VALVES

Carbon is generally said to be the cause of leaky valves. More careful study of the matter develops that it is not carbon but rather particles of sand and grit, coated with carbon, that hold the valves open. Carbon, itself, results from partly-burned gasoline or oil and is not hard but soft and extremely fine like lampblack and would tend to make the valves seat more closely. Moreover, it is the exhaust-valves that give the most trouble; these become so hot that carbon itself would readily burn, but the sand particles resist the hot gases and mix with the carbon, collecting on the valves and causing them to leak.

Every experienced operator knows that, when a certain amount of wear has taken place in an engine, it must be overhauled in order to give good service. Many large operators completely overhaul the entire machine after about 2 years of service.

Good examples of the actual cost of overhauling an engine, and of the relative cost of overhauling the complete vehicle, are given in a recent article¹ by E. E. La Schum, of the American Railway Express Co. That company operates over 2500 gasoline vehicles, and it may be assumed that the costs are similar to those of other large operators who maintain efficient repair-shops and have some advantage in buying parts in large quantities.

An examination of the data submitted shows that the cost of overhauling an engine, exclusive of the carbureter and the magneto, is more than \$550. This represents nearly 40 per cent of the cost of overhauling the entire vehicle. It is obvious that wear of the moving parts is the principal reason for such overhauling. It is equally obvious that any device that will prevent to a considerable extent such wear should be considered by manufac-

turers of equipment, whose primary duty is to furnish transportation at as low a cost as possible.

Data are available showing that an efficient air-cleaner will reduce considerably the wear of moving parts of engines that results even under the most favorable operating conditions, as when running on improved highways and so-called clean pavements in cities. Under the severe conditions encountered by farm and industrial tractors on account of dust and grit, and by trucks working in coal, sand and gravel, the wear on the engine may be reduced by 75 to 90 per cent. The following cases, which can readily be verified, represent the results that can be obtained by preventing all the dust and the grit from entering the carbureter and the combustion-chamber.

BENEFITS DERIVED FROM FILTERING AIR

An industrial tractor working in a large foundry required overhauling every 3 months, which cost about \$150. After applying an efficient air-filter, the same machine was operated for more than 24 months without being out of service for engine repairs.

One of the highest-grade American cars was driven by an engineer for 15,000 miles, including a trip across the continent and back and taking in the entire Pacific Coast, the alkali belt and the Pike's Peak hill-climb. The engine was examined, at the factory where the car was built, for wear on the cylinder walls, after this mileage had been made. The wear was found to be 0.001 in., which is about one-third the usual amount of wear on engines of the same make that cover the same amount of mileage, even though operating under the most favorable conditions.

A light six-cylinder coupe was driven 12,000 miles. About one-half the mileage was on improved highways and the remainder on city pavements. Careful measurements of the cylinders showed the wear to be less than 0.0007 in. The usual wear on this same make of engine is about 0.001 in. for each 5000 miles of service. A good grade of oil was used in this test and was changed after each 1000 miles.

An engineer who is responsible for the operation and maintenance of one of the largest motor-vehicle fleets in the United States and has extensive laboratory facilities at his disposal, made careful measurements of the cylinders, pistons and ring-groove clearances of two brand-new high-grade four-cylinder truck engines of the same make and model. These engines were connected to block-test dynamometers. A dust-box, about 8 ft. high, 4 ft. wide and 3 ft. long, was provided. In the bottom of the box was placed a quantity of actual road dust, which was kept agitated by a fan so that the lighter particles that would float readily in the air would rise to the top of the box. Dust-proof flexible tubing was used to connect the carbureter air-intakes with the inside of the dust-box. Both these tubes terminated near the

TABLE 1—MEASUREMENTS OF WEAR IN ENGINES

Name of Part	With Filter, In.	Without Filter, In.	Relative Wear
Cylinder Walls	0.0011	0.0090	1:8
Pistons	0.0005	0.0036	1:7
Upper Ring-Groove Clearance	0.0110	0.0650	1:6
Middle Ring-Groove Clearance	0.0040	0.0660	1:16
Lower Ring-Groove Clearance	0.0014	0.0230	1:16
Percentage of Incombustible Matter in Carbon	6.5000	31.0000	1:5

¹ See *Power Wagon*, April, 1924, p. 19.

top of the box. Inside the box an efficient air-filter was connected to one of the tubes so that all the air entering the engine was protected against dust and grit. The opening in the other tube was left unprotected. The engines were run about 240 hr. at the normal governed speed and load, after which they were taken down and measurements again were taken of the cylinders, pistons and ring-groove clearances. The average wear is given in Table 1.

It was further observed that the oil consumption was 40 per cent greater during the last 80 hr. of the test. From these results it can readily be seen that preventing road dust from entering an engine will very materially decrease the wear of the moving parts, and reduce the formation of so-called carbon that consists of various percentages of silicon and other incombustible matter. This formation on exhaust-valves and on the upper edges of the pistons will show from 65 to 75 per cent of incombustible matter, while the formation as a whole may not show more than from 15 to 25 per cent.

REQUIREMENTS OF A FILTER

Since it has been found desirable to keep road dust and grit out of an engine, the most important characteristic of a filter is high efficiency. Some engineers and superintendents in charge of operating fleets have expressed the opinion that it is necessary to remove only the large particles of grit from the air-supply. There is some advantage in keeping out the coarser particles. It has been found, however, that the finer particles are the more destructive. In certain sections of the Pacific coast territory, where the most trouble with engines is experienced, the dust is extremely fine and floats in the air at very low wind-velocities. A higher percentage of the coarser particles of sand and grit is blown out through the exhaust, while the very fine particles adhere to the thin oil-film on the cylinder walls. These small particles also work into the space between the piston and the piston-rings and the cylinder walls, and between the piston-rings and the ring grooves. Furthermore, when the abrasive particles reach the crankcase, the fine particles tend to stay suspended in the oil, while the coarser particles settle to the bottom of the crankcase. To be effective, the filter, or other device for excluding dust and grit from the air, must remove a very high percentage of any kind of dust or grit and function efficiently at any engine speed.

Other desirable requirements for a satisfactory filter are low resistance, or restriction, to the flow of air, durability and the minimum amount of attention. It is

also desirable that it be reasonably small in size and light in weight and have as few moving parts as possible. For use on passenger cars it is important that it be neat in appearance. Some filters produce a very good muffling effect on the noise caused by the inrush of air into the carbureter. This is especially noticeable on some cars and is very much appreciated by owners of high-grade automobiles.

Filters that reasonably meet all these requirements may now be had at a cost that is extremely small when compared with the benefits to be derived from their use, and their general adoption as equipment by manufacturers and purchasers is gradually taking place.

AIR-FILTERING IMPROVES ENGINE PERFORMANCE

Manufacturers spend large sums of money on advertising to make their products known, create interest in them and develop prospects for distributors and dealers. Inquiries made of several dealers reveal that a large percentage of buyers act on the recommendation of enthusiastic owners. It would, therefore, seem to be fully as good advertising and salesmanship as it is good engineering to adopt as equipment an air-filter that will greatly improve the performance of the engine, which is the most important unit and the one that indicates best the individuality of the car.

Great improvements have resulted in the production of more efficient, more quiet and more flexible engines. Improved methods of cooling and better lubricating systems have been worked out. But has as correspondingly great an advance been made in the way of making engines operate for longer periods without requiring repairs and overhauling?

A questionnaire sent out by the National Automobile Chamber of Commerce shows that owners specify long life or uninterrupted performance as the most desirable quality of an engine. Great progress has been made in the matter of durability and longer life of other parts of an automobile. Ten years ago tires that gave 5000 miles of service were considered good. Today they give 15,000 miles and upward, notwithstanding the fact that the price has been greatly reduced. Anti-friction bearings and improved lubricating-systems have greatly reduced the wear and have given longer life to many parts of the chassis, so that a correspondingly great increase in the life of the engine is needed to keep pace with the other developments that reduce operating cost. The use of an efficient air-filter will greatly lengthen the life of an engine and reduce the cost of operating any motor-vehicle on which it may be installed.

AUTOMOBILE ECONOMICS

IN 1913 1,258,000 motor vehicles were in use in the United States. In 1923 this number was over 15,000,000, an increase of over 1100 per cent in 10 years. In 1915 the gross revenues of the railroads of this Country were \$2,871,000,000. Last year they were in excess of \$6,500,000,000. Our railroads in 1923 hauled 1,277,000,000 loaded freight-cars, and the wages paid to the employees totaled approximately \$2,800,000,000, or an amount equal to the sum of the total gross receipts of the railroads in 1915.

During the 10 years from Jan. 1, 1914, to Jan. 1, 1924, the American public invested or spent \$17,000,000,000 for motor vehicles, an average of \$1,700,000,000 a year. During the same period total deposits in all banks increased from \$18,517,000,000 to \$40,000,000,000, and saving banks deposits

increased from \$4,936,000,000 to \$7,897,000,000. Building and loan associations' assets increased from \$1,248,000,000 to \$3,342,000,000, while life insurance in force, both ordinary and industrial types of policy, increased from \$21,565,000,000 to \$56,000,000,000.

In the face of these facts, can we say that the enormous expenditure made by the American public yearly for motor transport, including last year, in addition to over \$3,000,000,000 for vehicles and parts, over \$1,000,000,000 for gasoline and over \$900,000,000 for highway improvement is merely the gratification of an extravagant impulse? Is it not more evidently the investment of capital in a form of transportation that means greater efficiency and serves and saves rather than costs the Nation money?—Alvan Macauley.

Factors Affecting the Rate of Crankcase-Oil Dilution

By JOHN O. EISINGER¹

SEMI-ANNUAL MEETING PAPER

Illustrated with DIAGRAMS

THIS paper deals with progress in the Cooperative Fuel Research since the last report was presented to this Society. Previous tests had shown that the temperature of the jacket water exerted a major influence on the rate of dilution of crankcase oil. The reason for this influence was investigated and it was concluded that it was due to differences in the rate at which diluent was added to or eliminated from the oil-film upon the cylinder walls, the temperature of this film being dependent upon the temperature of the jacket water. Experiments failed to show that changes in the temperature of the piston head or changes in the viscosity of the oil upon the cylinder walls exerted a major influence upon the rate of dilution. These conditions were investigated as being probable consequences of a change in the temperature of the jacket water.

Evidence is presented which demonstrates that under certain conditions the diluent may be eliminated from the oil at a fairly rapid rate. The bearing that this has upon the possibility of an equilibrium state being reached is discussed. Considerable miscellaneous information is presented which relates to the manner in which dilution takes place and the influence of various conditions upon its rate.

THIS paper deals with the progress that has been made in the Cooperative Fuel Research since the last report² was presented to this Society in January, 1924. In nearly every report the general aims of the investigation have been stated and they need not be repeated here. It will be recalled that the chief obstacle to the use of fuels of low volatility was shown to be the high rates of crankcase-oil dilution that resulted. This led the Steering Committee of the cooperating organizations to recommend that further efforts be directed to a study of the factors affecting crankcase-oil dilution. The Committee also recommended that some attention be given to the subject of starting. Both of these problems are to receive further study.

In a report³ presented to this Society a year ago, the late S. M. Lee showed that the temperature of the jacket water exerted a marked influence on the rate of dilution; more dilution occurring when operating with cold jacket-water than when operating with hot. It appeared logical to endeavor to ascertain why this influence should exist.

Three explanations suggested themselves. Perhaps the most obvious explanation was that this influence was due to changes in the rate at which the diluent was eliminated from the oil upon the cylinder wall, this rate being dependent upon the temperature of the jacket water. Reluctance in accepting this explanation can be ascribed to the fact that the temperature of the initial point of diluent recovered from crankcase oil ordinarily

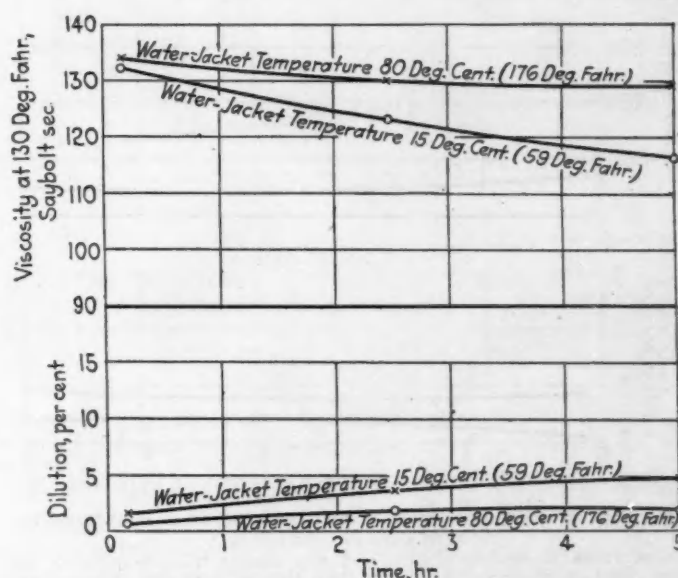


FIG. 1—EFFECT OF JACKET-WATER TEMPERATURE UPON THE RATE OF DILUTION OF CRANKCASE OIL

The Fact That the Amount of Dilution Is Much Less than That Obtained under Similar Conditions with the Engine Used in the Previous Tests Is Significant as Indicating That Design Characteristics Exert No Little Influence on the Rate of Dilution

is much higher than the highest jacket-water temperature employed.

The second explanation was suggested by some measurements of piston temperature made by Jehle and Jardine.⁴ They found that with a change in jacket-water temperature occurred a similar but very much greater change in the piston-head temperature. If then the temperature of the piston head is intimately related to the rate of dilution, it follows that a material change in its temperature, such as might result from a change in jacket-water temperature, would change the rate of dilution.

The third explanation relates to the viscosity of the oil upon the cylinder walls. This viscosity changes with each change of jacket temperature. It was not difficult to suppose that as the oil became more viscous, it might be less completely distributed around the piston and hence be less effectual in preventing the passage of fuel from the combustion-chamber to the crankcase.

DESCRIPTION OF ENGINE USED AND TEST PROCEDURE

Before discussing how each factor was investigated, a few comments as to the type of engine employed and the general method of test appear to be in order. The engine selected for previous work was chosen solely because it was of a type in wide-spread use. For the work here reported this qualification seemed less essential than that the engine should be of such rugged construction as to require overhaul at only infrequent intervals. The engine chosen, which will hereinafter be

¹ Assistant mechanical engineer, Bureau of Standards, City of Washington.

² See THE JOURNAL, March, 1924, p. 267.

³ See THE JOURNAL, July, 1923, p. 12.

⁴ See THE JOURNAL, September, 1922, p. 226.

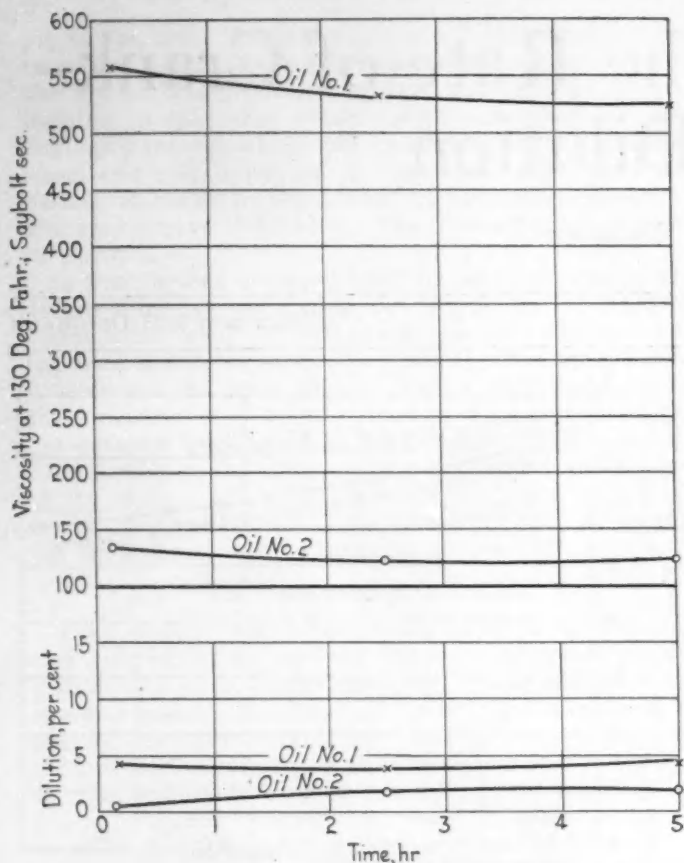


FIG. 2—HOW THE VISCOSITY OF THE OIL AFFECTS THE RATE OF CRANKCASE-OIL DILUTION

These Runs Were Made with a Water-Jacket Temperature of 80 Deg. Cent. (176 Deg. Fahr.) on Two Oils of Different Viscosities. The Particulars of These Oils Are Given in Table 1

designated Engine B, was a four-cylinder truck engine having a bore of $4\frac{3}{4}$ in. and a stroke of 6 in. Reference is also made to Engine A, which was a four-cylinder, overhead-valve type having a bore of 3 in. and a stroke of $4\frac{1}{4}$ in. The virtue of this engine consisted solely in the fact that it was mounted and available for test at a time when difficulties and delays were being experienced in the installation of Engine B. For the most part the use of Engine A has been restricted to the obtaining of preliminary and qualitative measurements.

The method of test was similar to that described in previous reports. After the engine had been operated until the desired temperatures had been attained and the necessary adjustments made it was flushed with a definite quantity of the oil to be used in the test. This flushing was accomplished by driving the engine for 5 min. by the dynamometer, after which the engine was again drained. The engine was then charged with new oil and the test started. In each run the power and the mixture-ratio were adjusted to be substantially the same as in the preceding run, the mixture-ratio employed being that giving maximum power. For convenience Engine B was operated in most instances at a speed of 1000 r.p.m. and about one-third load, while Engine A was operated at 1100 r.p.m. and about two-thirds load.

Oil samples consisting of 16 oz. each were taken 10 min. and $2\frac{1}{2}$ and 5 hr. after starting. The importance of taking samples at the end of the first 10-min. period will be apparent from the results here presented. Very frequently these samples show differences in dilution which are out of all proportion to the difference in the

dilution rate shown for the $2\frac{1}{2}$ and 5-hr. periods. The inference is that, in spite of the precautions taken in draining the engine, a sufficient quantity of used oil remained to dilute the fresh charge. Approximately the same amount of dilution was found in samples drained from the crankcase at the beginning of the run as at the end of the 10-min. period, showing that the rate of dilution was not excessively high during this time. No high rate would be expected as engine temperatures were for the most part normal. For comparative purposes it probably would be justifiable in most cases to take the dilution at the end of this first 10-min. period as a zero of reference and to subtract the actual reading at this time from the readings at the end of the $2\frac{1}{2}$ and 5-hr. periods. There would be no question as to its justification were dilution solely dependent upon the rate at which fuel is added to the oil. The objection to this procedure lies in the fact that the rate at which the diluent is eliminated from the oil also enters the problem and this rate depends upon the extent to which the oil has been diluted. All these facts have been given consideration in drawing conclusions, but measurements of dilution have been plotted as they were obtained with no corrections applied.

The percentage of dilution was determined by a method that is being developed at the Bureau of Standards. A brief description of this method appears in the appendix.⁵ How satisfactory it may prove for general use remains to be determined. As in the earlier work, Saybolt viscosities at 54 deg. cent. (130 deg. fahr.) were also determined.

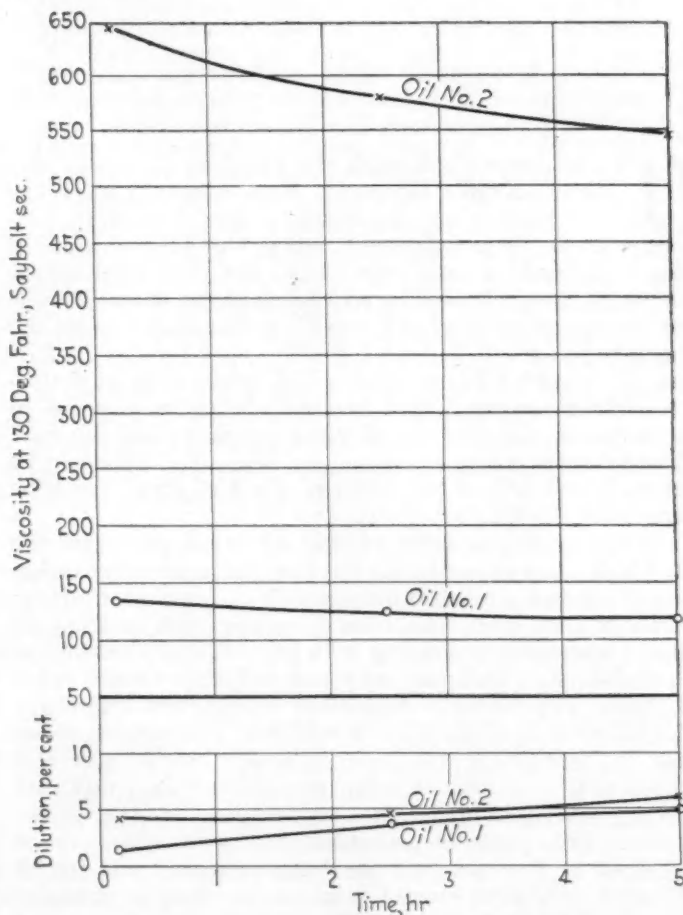


FIG. 3—CURVES SHOWING THE EFFECT OF THE VISCOSITY OF THE OIL ON THE RATE OF CRANKCASE-OIL DILUTION

These Runs Were Made on the Same Oils That Gave the Results Plotted in Fig. 2. In This Instance the Water-Jacket Temperature Was Only 15 Deg. Cent. (59 Deg. Fahr.)

⁵ [This will, it is expected, be published in the August number of THE JOURNAL.]

EFFECT OF JACKET-WATER TEMPERATURE

Before undertaking to find which was the correct explanation for the influence of jacket-water temperature upon crankcase-oil dilution it was obviously wise to make sure that this engine also gave evidence of such influence. Fig. 1 shows this to be the case. The fact that the amount of dilution is much less than that obtained under similar conditions with the engine used in the previous tests is significant as indicating that design characteristics have no little influence on rates of dilution.

TABLE 1—CHARACTERISTICS OF THE CYLINDER LUBRICANTS USED

Oil No.	No. 1	No. 2
Viscosity at 130 Deg. Fahr., Saybolt sec.	141	705
Viscosity at 210 Deg. Fahr., Saybolt sec.	52	128
Flash Point, deg. fahr.	395	515
Fire Point, deg. fahr.	460	585
Specific Gravity	0.899	0.892

To find whether or not the influence of jacket-water temperature was due to its effect upon the viscosity of

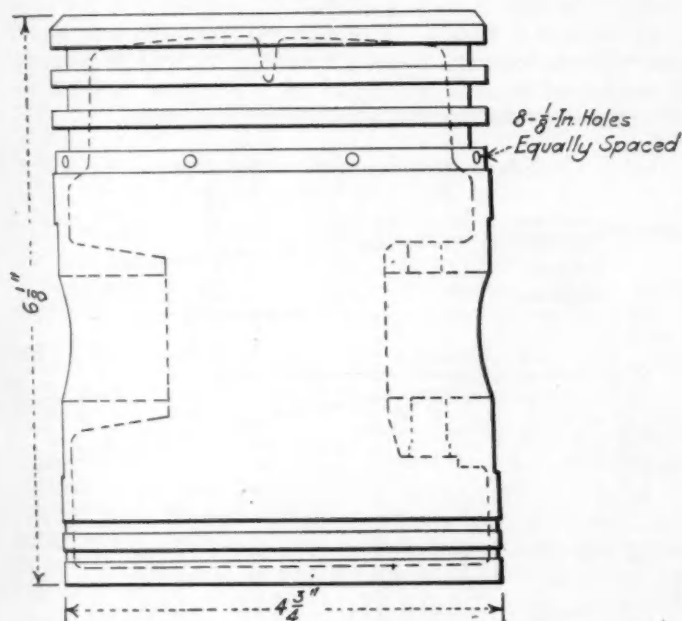


FIG. 4—TYPE OF PISTON USED IN ENGINE B IN MAKING THE TESTS. Only One Piston-Ring Was Used in the Tests To Determine the Effect of a Change in the Piston-Head Temperature on the Rate of Dilution

the oil upon the cylinder walls it appeared only necessary to make comparative tests at the same jacket temperature using oils of radically different viscosities. The oils selected were designated No. 1 and No. 2 and had the characteristics given in Table 1.

Fig. 2 shows the results obtained with hot jacket-water and Fig. 3 those obtained with cold. It is unfortunate that Oil No. 2 should have contained some constituents more volatile than the heavy ends of the gasoline used, as these are undoubtedly responsible for the high percentages of apparent dilution at the end of the 10-min. period and to some extent should be held accountable for the fact that the increase in dilution during the 5-hr. period was so small. In spite of this fact, when one observes the enormous difference between the viscosities of the two oils, he cannot help but be convinced that the two oils would have shown more radical differences in dilution were the effect of jacket-

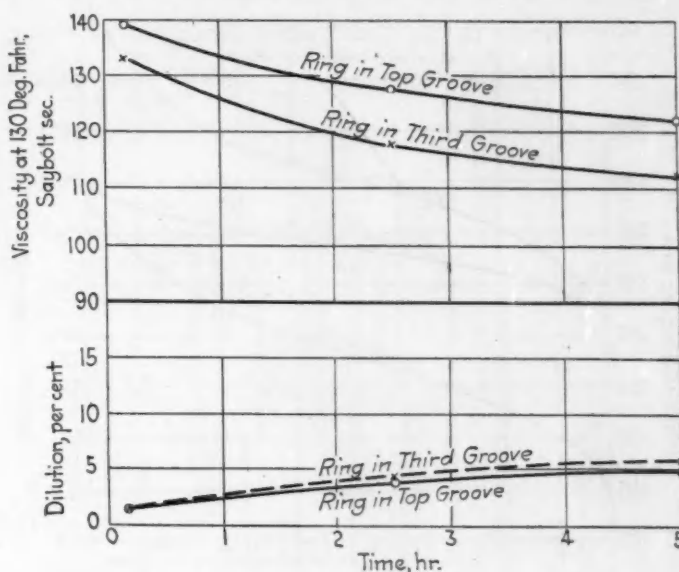


FIG. 5—EFFECT OF THE PISTON TEMPERATURE UPON THE RATE OF CRANKCASE-OIL DILUTION

These Tests Were Made at a Water-Jacket Temperature of 15 Deg. Cent. (59 Deg. Fahr.) and the Oil Holes Plugged. The Temperature Variation in the Piston Head Was Secured by Having the Rings in the Top Groove in One Instance and in the Bottom Groove in the Other. In the Latter Case No Opportunity Was Afforded for Any Considerable Amount of Heat Dissipation from the Portion of the Piston-Head above the Ring

water temperature due to its influence on the viscosity of the oil upon the cylinder walls.

PISTON-HEAD TEMPERATURE AND THE DILUTION RATE

Fig. 4 shows the type of piston used in Engine B. To ascertain the effect of a change in the temperature of the piston head upon the rate of dilution it was desired to make tests with the piston head at two different temperatures. To accomplish this runs were made using but one piston-ring, the ring in one instance being in the top groove of the piston and in the other instance

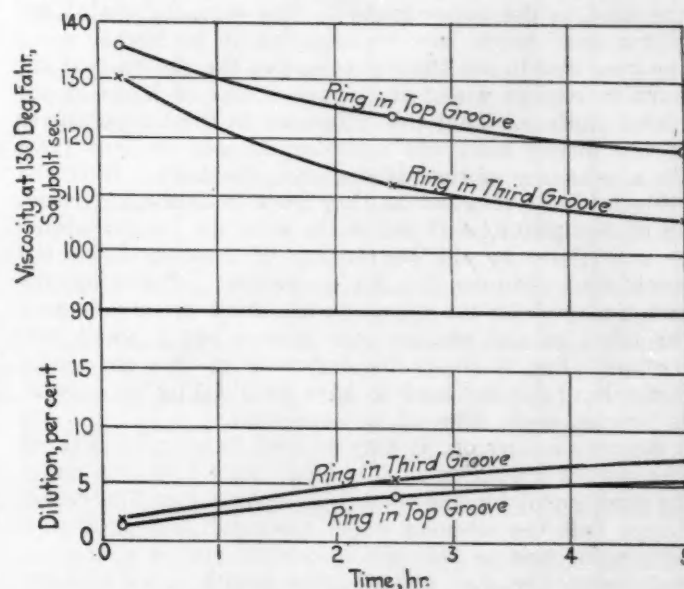


FIG. 6—CURVES SHOWING THE EFFECT OF BLOW-BY UPON THE RATE OF CRANKCASE-OIL DILUTION

The Results Plotted in These Curves Were Obtained under the Same Conditions as Regards the Water-Jacket Temperature and the Position of the Piston-Ring as Those Shown in Fig. 5. The Oil Holes, However, Were Open During These Tests, as They Would Be in Normal Engine Operation. Since the Effective Length of the Oil Seal Was the Distance between the Piston-Ring and the Oil Relief Holes, Changing the Piston-Ring from the Top to the Third Groove Reduces Materially the Length of the Effective Oil Seal and Blow-By Takes Place. It Should Be Noted However That the Influence of Blow-By upon the Rate of Dilution Is Slight

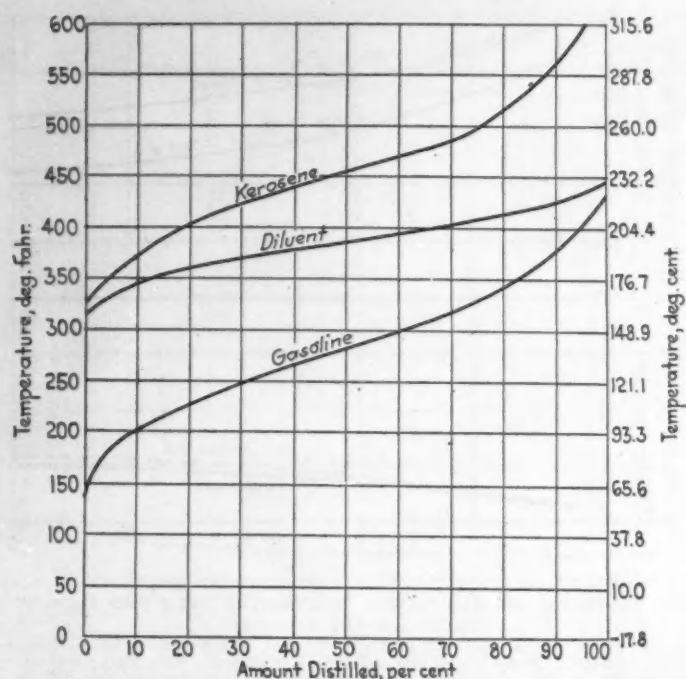


FIG. 7—DISTILLATION CURVES OF KEROSENE, GASOLINE AND A DILUENT FROM ONE OF THE TEST RUNS

The Kerosene Was Used To Produce Artificially Diluted Oil for a Subsequent Series of Tests, the Gasoline Was That Used as Fuel in All the Test Runs and the Diluent Was Obtained from a Test Run at a Water-Jacket Temperature of 15 Deg. Cent. (59 Deg. Fahr.) with the Oil Holes Plugged and the Piston-Ring in the Third Groove. The Dilution Results Obtained in This Run Are Plotted in Fig. 5

in the third groove. Tests have shown that the greater proportion of heat dissipation from the piston to the cylinder walls takes place through the piston-rings. With the ring in the third groove no opportunity would be afforded for any considerable amount of heat dissipation from the section above the ring. Hence this section would be at a considerably higher temperature than with the ring in the upper groove. The temperature of the piston head might also be expected to be higher when the ring was in the third groove, for the reason that the burning charge would then have access to more of the piston surface. That the difference in the temperatures of the piston head was considerable was evident from the appearance of the pistons after the tests. With the oil-relief holes plugged, as they were in this comparison, all of the piston skirt below the ring can be considered to contribute to the prevention of leakage from the combustion-chamber to the crankcase. Changing the piston-ring from the upper to the third groove changes the effective seal against gas leakage but a small percentage. Fig. 5 shows the influence of this change in piston-head temperature to have been negligible insofar as crankcase-oil dilution is concerned.

Before passing on, it may be well to consider Fig. 6. The results presented in this chart were obtained under the same conditions as those upon which Fig. 5 is based, except that the oil-holes under the conditions of Fig. 6 were wide-open as they are in normal engine operation. Such being the case, the effective length of oil-seal becomes the distance between the piston-ring and these relief-holes. Under such circumstances, moving the piston-ring from the top to the third groove effects a large-percentage reduction in the length of effective oil-seal. With the ring in this position an excessive amount of fumes issued from the crankcase, giving additional proof that "blow-by" was taking place. Fig. 6 furnishes evidence that this was the case, by showing more dilu-

tion to have occurred when the ring was in the third groove than when it was in the top groove, despite the higher piston-head temperature under the former condition. Insofar as the evidence presented in this figure is concerned, the influence of blow-by upon rate of dilution is slight.

EFFECT OF CHANGES IN OIL-FILM TEMPERATURE

From the foregoing it appears that neither the change in the temperature of the piston head nor the change in the viscosity of the oil upon the cylinder walls can account for the relation between the temperature of the jacket water and the rate of dilution. It appears, therefore, that the explanation must be in the effect that a change in the temperature of the oil-film on the cylinder walls has upon the rate at which the diluent is added to or eliminated from that film. In this connection the results of a test with Engine A are illuminating. This engine was supplied with an oil that had been prepared by mixing 30 per cent of kerosene with 70 per cent of oil No. 1. The engine was driven by a motor for 5 hr., no fuel being supplied and no combustion occurring in the cylinders. The jacket-water temperature was 38 deg. cent. (100 deg. Fahr.) and the oil temperature 39 deg. cent. (102 deg. Fahr.). Although the kerosene was much less volatile than the diluent (see Fig. 7) that ordinarily is recovered from a crankcase oil, a decrease in dilution of 7 per cent during the 5-hr. period was noted.

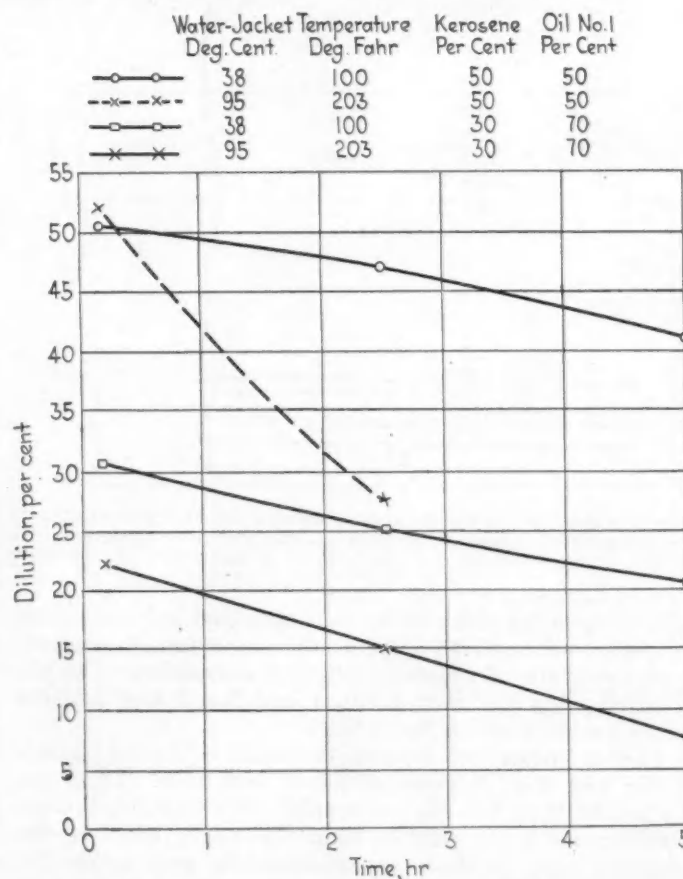


FIG. 8—RESULTS OF TESTS WITH ARTIFICIALLY DILUTED OILS
These Tests Were Made on a Four-Cylinder Overhead-Valve Type Engine Having a Bore of 3 in. and a Stroke of 4 1/4 in. That Was Driven by a Motor for 5 Hr., No Fuel Being Supplied and No Combustion Occurring in the Cylinders. This Engine Was Supplied with an Artificially Diluted Oil That Had Been Prepared by Mixing 30 Per Cent of Kerosene with 70 Per Cent of Oil No. 1 and Tests Were Made at Water-Jacket Temperatures of 38 Deg. Cent. (100 Deg. Fahr.) and 95 Deg. Cent. (203 Deg. Fahr.). The Tests Were Repeated at These Temperatures with a Mixture Consisting of Equal Parts of Kerosene and Oil No. 1. In Every Case the Rate of Dilution Decreased Decidedly as the Tests Progressed

It will be recalled that with the engine used in previous tests a run of 15 hr. was made, at the end of which the viscosity at 100 deg. fahr. of the lubricant was 93 Saybolt sec. whereas that of the unused oil was 290. No indication was apparent that a continuation of the test would have resulted in the reaching of an equilibrium state where the diluent would be eliminated at a rate equal to that at which diluent was added. Other investigators had frequently reported finding such a condition, which presupposes a fairly rapid rate of elimination of diluent from crankcase oil. To see if such a condition existed, Engine A was operated both with oil diluted with 50 per cent of kerosene and with oil

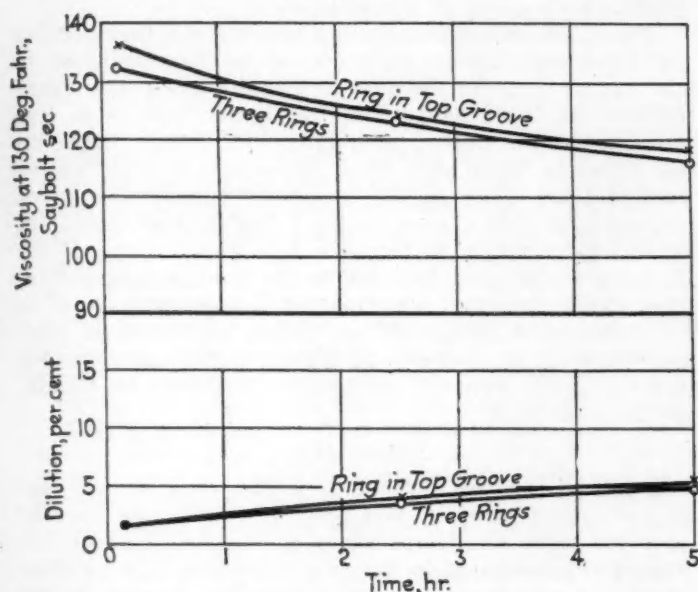


FIG. 9—EFFECT OF THE NUMBER OF PISTON-RINGS UPON THE RATE OF CRANKCASE-OIL DILUTION

These Tests Were Made at a Water-Jacket Temperature of 15 Deg. Cent. (59 Deg. Fahr.) with the Oil Holes Open at One-Third Load and a Speed of 1000 R.P.M. Under the Conditions at Which the Results Plotted Were Obtained, the Dilution Was Not Appreciably Greater When Using Only One Piston-Ring than When Using All Three

diluted with 30 per cent of kerosene, tests with each oil being made with the jacket water both hot and cold. Fig. 8 shows that in every case a decided decrease in dilution was noticed as the test progressed. It would appear, therefore, that the engine used in the previous tests permitted the diluent to be added to the oil at so rapid a rate as to mask any effect due to the elimination of the diluent if such elimination took place.

OTHER FACTORS AFFECTING DILUTION

It seems desirable at this time to direct attention to some factors other than those related to jacket-water temperature which are being investigated with reference to their influence upon dilution, even though it may be necessary to defer the drawing of conclusions as to the extent of this influence until later. These include (a) piston seal, (b) quantity of oil, (c) rate of oil circulation and (d) amount of cylinder surface exposed to the charge.

Fig. 9 shows that under the conditions of operation in these tests, one-third load at 1000 r.p.m., dilution was not appreciably greater when using only one piston-ring than when using all three.

That the percentage of dilution is affected by the quantity of oil in the system is appreciated generally. Obviously, if the amount of oil to which the diluent is added is reduced and the rate at which the diluent is added is not changed, the percentage of dilution at the

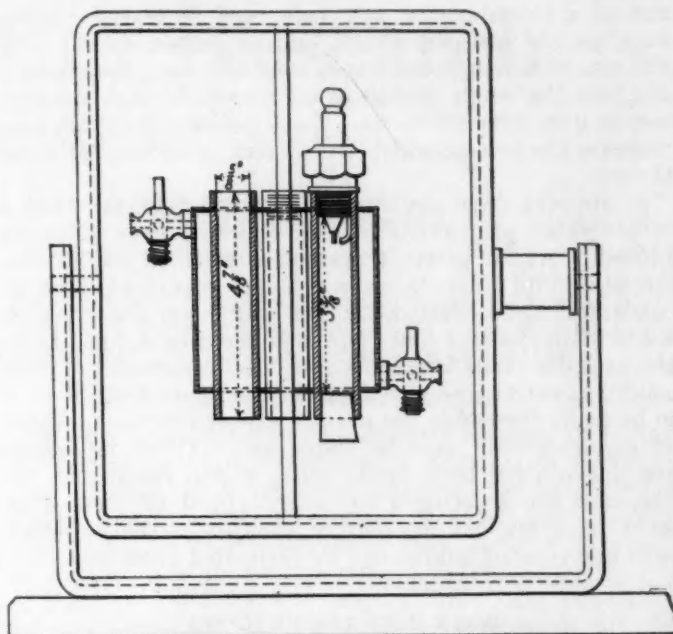


FIG. 10—BOMB USED IN THE STUDY OF STARTING AND DILUTION PROBLEMS

This Bomb Was Constructed Not To Obtain Precise Measurements of Any Particular Property of a Fuel But Rather with the Idea That It Might Furnish a Convenient Means for Detecting Certain Differences in Fuel Characteristics. The Device Consists of a Group of Four Tubes Capable of Rotation in Perpendicular Planes and Provided with a Jacket through Which Liquid Can Be Circulated To Bring the Tubes to Any Desired Temperature. In Operation Liquid Fuel Is Introduced into the Tube at Atmospheric Pressure. One End Is Closed with a Stopper and the Charge Is Ignited from the Spark-Plug That Closes the Other End

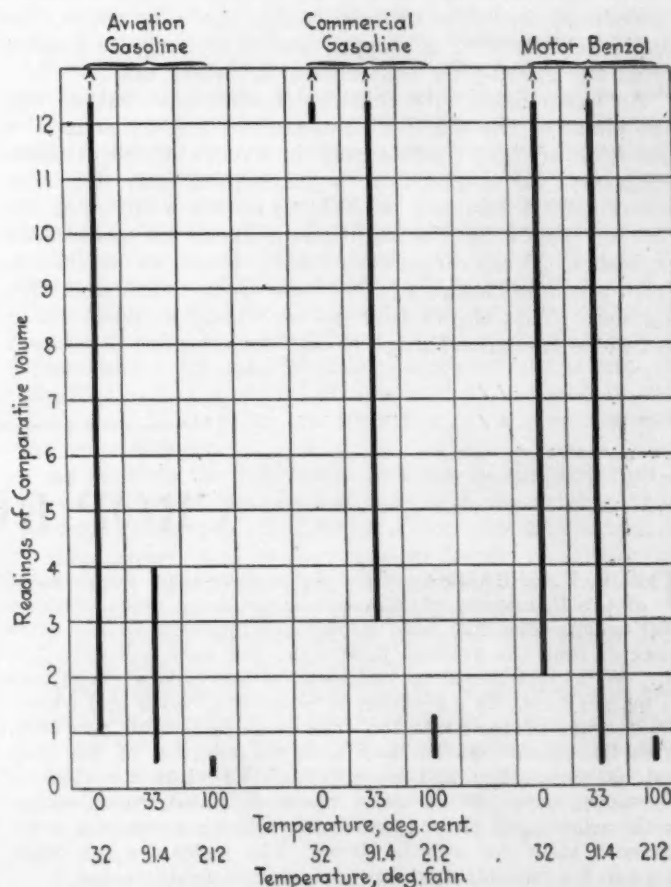


FIG. 11—CHART SHOWING THE QUANTITIES OF FUEL WITH WHICH COMBUSTIBLE MIXTURES WERE OBTAINED

The Volume Scale Is Entirely Arbitrary. This Chart Is of Interest in Connection with the Starting Problem as Providing a Picture of the Task Imposed upon the Carburetor

end of a given period will have been increased. However, as the quantity of oil in the system is reduced, the rate at which it circulates, that is to say, the number of times the whole charge of oil passes through the system in unit time, increases. Tests indicate that this may increase the rate at which the diluent is eliminated from the oil.

It appears from the results obtained thus far that a considerable proportion of the dilution takes place as follows: As the piston travels downward on the suction stroke, liquid fuel is collected, or vaporized fuel is condensed and collected, by the oil-film on the cylinder walls. Some of this film eventually becomes scraped from the cylinder walls and falls into the crankcase. If this condition exists, one would expect the amount of dilution to be dependent upon the area of exposed surface. Time of exposure may also be important. These influences are linked with bore-stroke ratio, piston speed and the like, and are mentioned as being typical of those that must be evaluated before the dilution to be expected with one type of engine can be estimated from measurements made with another.

BOMB USED IN THE TESTS

The bomb shown in Fig. 10 was not constructed for the purpose of obtaining precise measurements of any particular property of a fuel, but rather with the idea that it might furnish a convenient means for detecting certain differences in fuel characteristics. The device consists of a group of four tubes capable of rotation in perpendicular planes and provided with a jacket through which liquid can be circulated to bring the tubes to the desired temperature. In operation, liquid fuel is introduced into the tube at atmospheric pressure, one end is closed with a stopper and the charge is ignited from the spark-plug that closes the other end.

An experiment with this device illustrates rather well one phase of the dilution problem. In this experiment a quantity of fuel considerably in excess of the amount necessary for combustion is introduced into the tube, whereupon it becomes possible to obtain a series of explosions solely by the addition of fresh air after each explosion. Very frequently more than 50 explosions from a single charge of fuel have been obtained in this manner. This shows that an individual explosion does not cause the vaporization of any considerable portion of

the fuel in the tube, much less its combustion. In the engine where the fuel may be intimately mixed with the oil upon the cylinder walls the likelihood that the excess fuel will be burned is even less.

Mixtures that could be fired resulted from introducing into the bomb liquid fuel in the quantities shown in Fig. 11. The volume scale is entirely arbitrary. From the standpoint of crankcase-oil dilution, interest centers in the difference between the mixture ranges at high and low temperatures. The difference between the minimum values indicates the excess fuel that must be supplied at the low temperature in order that sufficient fuel may be vaporized to permit combustion. The excess, unvaporized portion serves only to dilute the oil.

Fig. 11 is of interest in connection with the starting problem as providing a picture of the task assigned to the carbureter. If the fuel as distributed to the cylinders is for the most part in the liquid form, it is possible to obtain smooth operation with rather large inequalities in the distribution, provided but little vaporization takes place in the cylinder. When more rapid vaporization takes place in the cylinder, less inequality in the distribution is permissible. This is one of the few cases where an increase in the charge temperature may cause the engine to operate less smoothly. It is to some extent a "freak" condition, as manifold temperatures usually increase as rapidly as cylinder temperatures and the ease of distribution increases as rapidly as the need for it.

SUMMARY

Summarizing the foregoing, it has been shown that in the engine used in this test, as in the one used in previous tests, the temperature of the jacket water has a marked influence upon the rate of dilution. This difference does not appear to be due to the change in the viscosity of the oil upon the cylinder walls, or to a change in the piston-head temperature, but rather to the difference in the rate at which the diluent is added to or eliminated from the oil-film. It has been shown that under certain circumstances the diluent is eliminated at a fairly rapid rate and hence that an equilibrium condition may be reached at which the rate of elimination balances the rate at which diluent is added. Other factors are discussed with reference to their probable influence upon the rate of dilution.

CROP ROTATION

PROF. F. C. BAUER, of the Farm Extension Department of the University of Illinois, showed from actual records that where corn had been grown continuously on the same piece of land the average production per acre was only 27.3 bu. With oats added to the rotation the corn average was 37 bu. per acre. In a rotation of corn, oats, clover and wheat, the average of the State for corn alone is 55.6 bu. per acre. With this same rotation and with the addition of the crop residues, limestone and phosphorus, the yield for corn is 69 bu. per acre. When sweet clover is added, being seeded in the wheat and plowed under the following year for corn, the corn yield per acre is 83 bu. The yields for the other crops in the rotation are also correspondingly increased.

Professor Bauer said that, under these calculations, where corn is grown alone the cost per bushel is 85 cents. With corn, oats and clover, the cost per bushel is 58 cents. With corn, oats and the fertilizers, the cost is 40 cents; and when

sweet clover is added to the rotation as the green manuring crop, the cost per bushel is 36 cents.

His calculations also stated the fallacy of the common method of including interest on the investment in the farm, or the rental value, in the production cost, for he reversed the order of the calculation, showing that counting interest at 5 per cent, and assuming corn worth 40 cents per bu., oats 30 cents, wheat \$1 and legume hay \$10 per ton, the cash value of the land would be as follows: For corn continuously, the value per acre is worse than worthless, minus \$5.83 per acre; for the 3-year rotation the value per acre is \$105; for the 4-year rotation, \$157; and for the 4-year rotation with the green manure, \$316. These figures prove that it is useless to figure on what wheat crops ought to be worth from the price of the land; the correct process is to base the value of the land on the value of the crops it will produce.—G. E. Roberts.

Riding-Qualities Research

By JOHN A. C. WARNER¹

SEMI-ANNUAL MEETING PAPER

Illustrated with DRAWINGS AND PHOTOGRAPHS

THE ascertaining of the factors that determine the riding-qualities of automobiles and the methods employed in studying these factors, and consideration of the lines along which research should be directed in an effort to improve riding conditions, are proposed in this paper with a view to encouraging further helpful discussion of the riding-qualities problem.

Relative to the first of these questions, the factors treated in this paper comprise (a) road characteristics with respect to the vehicle; (b) the vertical, the longitudinal and the transverse motions of an automobile, as well as small vibrations or oscillations of high frequency; (c) vehicle characteristics, such as springing, accessory control, tires, wheels, chassis frame, seating, body, engine and transmission, steering-gear, brakes, heating, ventilating and lighting.

Four methods most frequently applied to the study of riding-qualities are those employing (a) direct observation by the experimenter, (b) accelerometer measurements, (c) seismograph measurements and (d) photographic analysis, including motion pictures and the photographing of lights suitably mounted upon the vehicle and its load. The requirements that must be fulfilled by instruments in this work are discussed, and several interesting designs of accelerometers and seismographs are described.

In considering the problem of future research, the author mentions as the aims of such investigation (a) accurate analysis of the motions and the forces to which an automobile passenger is subjected, (b) determining as definitely as possible the effects of these motions and forces upon the individual, (c) correlating the conditions with their proper sources and (d) remedying the causes of the uncomfortable or fatiguing conditions. It is shown that, although some study has been devoted to certain phases of the problem, no complete solution has been achieved because of a lack of coordination in the results. Recommendations for future work include (a) a study of the characteristics of vehicle motions with an instrument installation that will record simultaneously both the rotational and the translational effects that may be of importance, (b) an investigation of the effects of the prevailing motions upon individuals, by subjecting a large number of persons to laboratory tests in which riding conditions could be accurately reproduced with suitable apparatus, and by studying the results in close cooperation with physiological and psychological experts and (c) an endeavor to apply this information to the investigation of the influence exerted by the various components of the vehicle upon the motions.

WHAT are the factors that determine the riding-qualities of automobiles? How have these factors been studied? Along what lines should research be directed in order that improved riding conditions may be effected? These are the outstanding questions propounded by the present paper with a view to encouraging further consideration and helpful dis-

cussion of the riding-qualities problem. Numerous references are given as a possible aid to those who may care to examine the literature relating to this subject.

RIDING-QUALITY FACTORS

A complete analysis of all the important riding-quality factors would obviously include a full consideration of road characteristics. For the purposes of this paper, however, the problem will be treated mainly with respect to the vehicle, assuming that all prevailing road-conditions are to be encountered. Obviously, the important road factors are (a) regularity and smoothness of surface, (b) elasticity, (c) surface contour, (d) curvature and (e) visibility.

In general, the motions of an automobile may be considered as taking place along or around the three principal axes of the vehicle; vertical, longitudinal and transverse. From the standpoint of the passenger's comfort the relative importance of the various types of motion is not well defined, but it is nevertheless worthwhile to consider their possible causes and effects.

According to general belief, the vertical accelerations are responsible for the greatest degree of discomfort and fatigue, it being agreed that uniform velocity of motion with respect to any of the three axes has little or no direct bearing on the problem. It is possible, however, that the change of acceleration and its duration rather than acceleration itself may be most important.² Vertical accelerations caused by irregularities of road-surface or otherwise are felt by the passenger as pressures the characteristics of which depend upon the type and duration of the acceleration. Closely related to the straight vertical motions and perhaps equally severe in their effect are those due to pitching or rotation of the vehicle about a transverse axis. Such motions are often accompanied by rather sharp accelerations along the longitudinal axis of the vehicle and may result in very disagreeable snapping or whipping effects on the body of the passenger.

As regards the horizontal motions in the direction of travel, the accelerations and decelerations arising under normal conditions of driving from the application of engine-power and brakes are probably relatively unimportant physiologically. There may, however, be a considerable effect from the impulses that correspond to the horizontal components of impacts that result from striking obstacles on the road.

Transverse motions of noticeable magnitude are comparatively infrequent in normal driving. They are caused by the centrifugal force that accompanies motion along a curvilinear path and are probably of minor importance physiologically. The same remarks apply in general to the rotary motions, or yawing, that take place about the vertical axis.

Rotary motions about the longitudinal axis, or rolling, may be caused by road irregularities or to some extent by variations in engine torque. Their effect depends largely upon their magnitude and frequency, but they

¹ M.S.A.E.—Assistant manager of the research department, Society of Automotive Engineers, Inc., New York City.

² See *Proceedings of the Institution of Automobile Engineers*, vol. 2, p. 187, and vol. 7, p. 451; also *THE JOURNAL*, December, 1922, p. 553.

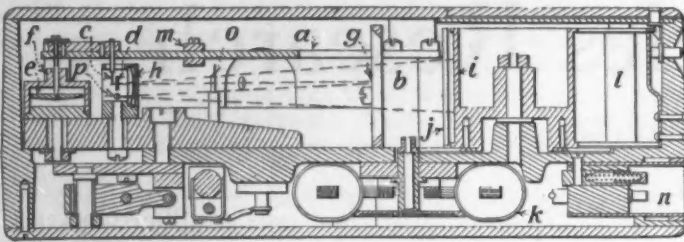


FIG. 1—CROSS-SECTION OF THE CANTILEVER-SPRING TYPE OF PHOTOGRAPHIC RECORDING ACCELEROMETER DEVELOPED TO MEASURE AUTOMOBILE ACCELERATIONS

The Design of This Instrument Is Based upon That of the National Advisory Committee for Aeronautics Aircraft Accelerometer also Developed by F. H. Norton. The Important Parts Are *a*, Flat Cantilever Spring; *b*, Spring-Base; *c*, Hardened Steel Stylus Transmitting Spring-Motion to the Mirror; *d*, Rotating Mirror; *e*, Damping Vane Working in the Dash-Pot; *f*, Oil Filled Dashpot; *g*, Light-Source; *h*, Lens; *i*, Record-Film; *j*, Vertical Slit for Limiting the Light-Beam; *k*, Constant-Speed Motor for Operating the Recording Mechanism; *l*, Record-Spools; *m*, Sensitivity Weight Adjustable along the Spring; *n*, Battery Plug; *o*, Signal-Lamp To Locate Any Event on the Film; *p*, Zero Mirror To Make Fixed Reference-Line on the Film. The Instrument Operates on a 6-Volt Battery and Is Small Enough To Be Carried in the Coat Pocket

are believed to be a secondary consideration under normal conditions.

In addition to the motions of appreciable amplitude there are the small vibrations or oscillations of high frequency which may exert a powerful effect so far as discomfort and fatigue are concerned. Noise and rattle come within this category. The influence of this type of phenomenon is subtle and a passenger may not even be aware of a more or less continuous high-frequency vibration that is in the aggregate very fatiguing. In this connection, as in general, the question of mental and nervous fatigue must be considered along with the strictly physiological aspects. Vision, air-reaction and temperature are among other factors that enter into the problem.

VEHICLE CHARACTERISTICS

When studying the various types of motion that may be encountered in an automotive vehicle, it is *primarily important* to recognize the possible effect upon the passenger or other load. However, another angle should not be overlooked, namely, that of the vehicle itself, for the forces that affect the passenger or the load also affect the vehicle; a relation exists between the stresses involved and the forces or accelerations that produce them. Thus, designing for comfort undoubtedly benefits the car as well as the passenger.

Among the main structural items related to vehicle design that have a direct bearing on the problem are: springing, accessory control, tires, wheels, chassis frame, seating, body, engine and transmission, steering-gear, brakes, heating and ventilating system and lighting. It is not within the scope of this paper to discuss the various phases of design and the way in which these factors enter. It is safe to assume, however, that they all should be given careful consideration from the riding-quality standpoint, both separately as individual units and collectively as parts of a complete assembly.

Some attention has been devoted by engineers to the performance testing of complete vehicles under the various operating conditions outlined above. The methods and instruments applied to this work as described briefly in the following paragraphs may be of interest.

The four methods most frequently applied to the study of riding-qualities are those employing (a) direct observation by the experimenter, (b) accelerometer measurements, (c) seismograph measurements and (d) photographic analysis. The last-named includes the use

of motion pictures and the photographing of lights suitably mounted upon the vehicle and its load.

DIRECT OBSERVATION

Much has been said and written about the reliability or unreliability of riding-quality analyses, based upon the "feelings" of an observer as he rides in a vehicle. Some people believe this personal-touch method to be eminently satisfactory and vastly superior to instrumental means for riding-quality investigations. They call attention to the sensitivity attainable by those best fitted for this work and emphasize the obvious simplicity and fundamental character of the method.

On the other hand, we find many experimenters who acknowledge that this method is perhaps useful for rough comparative determinations but recognize its serious inherent limitations. There is the lack of a fixed and determinate scale of measurement; the recording medium is a variable factor, influenced by many conditions; the records are uncertain, inaccurate and transient; and the diagnoses are seldom specific or sufficiently precise to be of real value in the attempt to improve conditions. The last statement applies in particular to the analysis of vibrations or shocks that are small individually but of great importance when considered in the aggregate.

Granting that this method is inadequate and unsatisfactory when considered by itself, nevertheless it seems probable that when properly combined with appropriate instrumental observations it should yield results of material value. This point will be further considered here-inbelow.

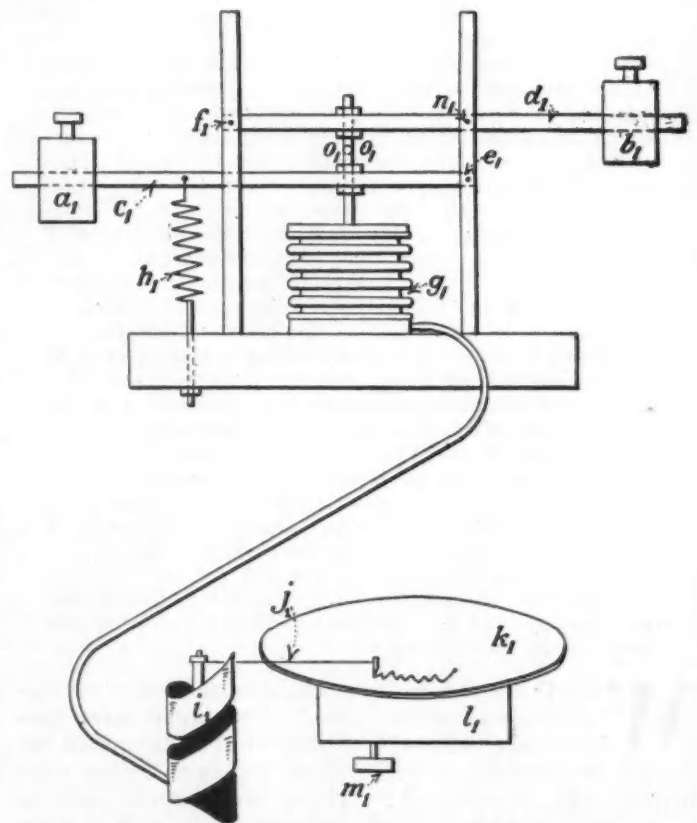


FIG. 2—DIAGRAMMATIC SKETCH OF THE SYLPHON TYPE OF ACCELEROMETER

This Instrument Developed under the Direction of Doctor Coffin in the General Laboratories of the United States Rubber Co. Combines the Following Important Elements: *a*, *b*, Inertia Masses adjustable in Position along the Lever-Arms *c*, *d*; *e*, *f*, Fulcrum-Points; *g*, Flexible Metallic Syphon; *h*, Tension Spring; *i*, Bourdon Tube Recording Element; *j*, Recording Pen-Arm; *m*, Governing Vane; *n*, Fulcrum Point; *o*, Center of Symmetry

ACCELEROMETER DESIGN

Accelerations along and around the three principal axes of a vehicle are undoubtedly among the most important factors that determine riding-comfort. Their measurement, by suitable accelerometers, constitutes a useful method for studying vehicle motions and for evaluating their effect upon the vehicle and its load.

A number of investigators, both in this Country³ and abroad,⁴ have developed instruments that merit the careful study of research men. Some form of inertia element is incorporated in them in such a manner that slight motions of the element when subjected to accelerations are magnified and are then recorded upon a suitable chart.

In the design of such instruments certain requirements

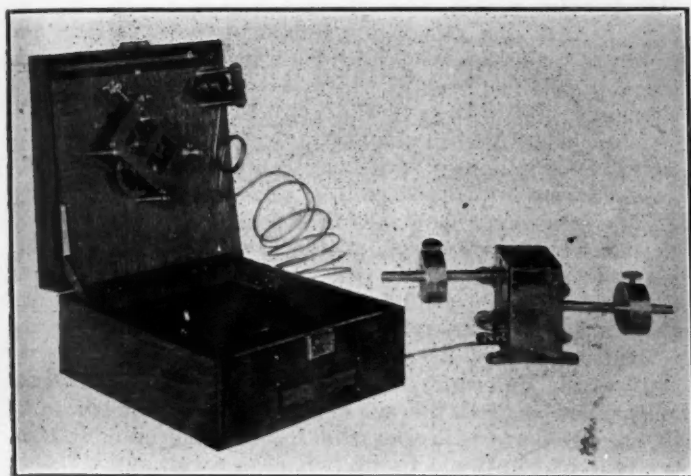


FIG. 3—SYLPHON TYPE OF ACCELEROMETER

The Sylphon and Inertia Elements Are Shown at the Right. This Assembly Is Connected with the Recording Element at the Left by a Flexible Metallic Tubing of Small Bore, as Explained in the Text

should be fulfilled.⁵ It is essential that the active element of the accelerometer have the highest natural period consistent with adequate deflection. This period should be high enough to measure the faithful recording of the highest-period accelerations to be measured. Were a relatively low natural period to be used, the instrument would get into resonance with the forced vibrations, and the records would be unreliable. Obviously, the motion of the inertia element should be very small, since an appreciable displacement, representing energy absorbed, would not allow the recording of true acceleration. Also, were the element to exhibit a sensible amount of motion, each succeeding impulse would find it in a different initial position, and varying degrees of response to the forces of similar impulses would be recorded. A further essential feature of a satisfactory accelerometer is the availability of sufficient energy from the operating ele-

³ See *Bulletin of the National Research Council*, vol. 6, part 4, No. 35.

⁴ See *The Engineer*, Sept. 16, 1910, p. 313, and Sept. 27, 1912, p. 338; also British Advisory Committee for Aeronautics Reports and Memoranda No. 376; also *Memoires et Compte Rendu des Travaux de la Societe des Ingenieurs Civils de France*, vol. 2, pp. 26 and 51; also *Comptes Rendus des Seances de l'Academie des Sciences*, vol. 169, p. 24; also *Bulletin de la Societe d'Encouragement pour l'Industrie Nationale*, vol. 134, p. 177; also *Engineering*, March 3, 1905, p. 274.

⁵ See National Advisory Committee for Aeronautics Technical Report No. 100.

⁶ See *THE JOURNAL*, February, 1924, p. 136.

⁷ See British Advisory Committee for Aeronautics Reports and Memoranda No. 376.

⁸ See National Advisory Committee for Aeronautics Technical Report No. 99.

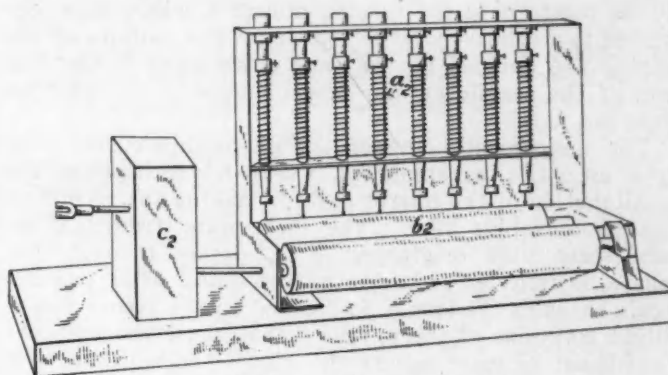


FIG. 4—THE NAVY ACCELEROMETER

This Instrument Developed under the Direction of A. F. Zahm in the Navy Department To Study Aircraft Landing Shocks Consists of a Number of Pointed Styluses, a_2 , Balanced against Helical Springs That Hold the Recording Points just above the Record-Chart b_2 until an Acceleration Overcomes the Effect of the Spring and Causes a Particular Stylus To Drop and Make a Mark on the Chart. The latter Is Moved by Clockwork c_2

ment to overcome all frictional and inertia resistances in the multiplying and recording or indicating mechanisms. In view of the very small motion of the inertia element, the necessary multiplication is relatively large and thus it may be expected that more or less frictional resistance will be introduced. The most commonly used accelerometers employ for their transfer and multiplying mechanism lever-linkages, gearing, optical levers or hydraulic arrangements. Several of the most interesting typical designs are briefly described below.

A CANTILEVER-SPRING ACCELEROMETER

In an article⁶ that merits careful reading, F. H. Norton describes riding-quality tests conducted with an accelerometer similar in design to the National Advisory Committee for Aeronautics type originally suggested by Prof. E. P. Warner and subsequently developed by Mr. Norton. Like the R.A.F. instrument,⁷ one of the first of the recording type, this accelerometer was originally conceived for airplane use.⁸ It was later redesigned and adapted very successfully by Mr. Norton to the testing of automobiles.

In the cross-section of the instrument shown by Fig. 1, a indicates the flat cantilever steel spring, rigidly fastened to the base b , and carrying at its free end the stylus c that transmits the slight motion of the spring

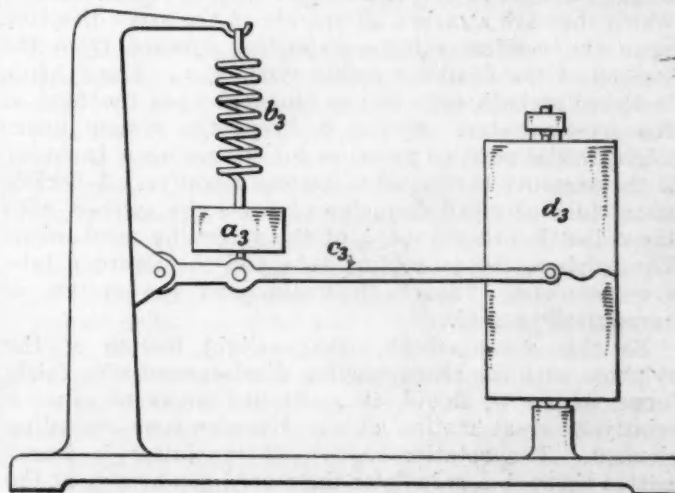


FIG. 5—SEISMOGRAPH ELEMENTS SHOWN DIAGRAMMATICALLY
The Inertia-Element a_3 Is Balanced against the Coil-Spring b_3 , So That Motions of the Frame of the Instrument with Respect to the Mass Are Recorded through the Pen Arm c_3 upon the Record-Chart d_3

to the platform of the rocking mirror d , where it is converted to a relatively large rotation. The motions of the spring are damped by the vane e , attached to the free end of the cantilever and free to move in the oil-filled dash-pot f .

The instrument being of the photographic recording type, an optical arrangement is used for multiplying the small motion of the mirror and for making the record on the photographic film. The light-beam from an incandescent bulb originates at g , passes through the lens h , is reflected from the mirror d and, after passing again through the lens h , is focused on the record film i . Slight rotations of the mirror d thus cause the reflected light-beam to move across the film. The width of the beam is regulated by a vertical slit, j , placed in front of the film. The multiplication of spring motion is ordinarily about 200 times, but this can be varied by changing the relative position of the stylus and the mirror staff. The sensitivity of the instrument can be adjusted by sliding the mass m along the spring, greater sensitivity being obtained as the weight is moved toward the free end.

The record-film is driven at a constant known speed by a specially constructed constant-speed electric motor, k . The film spools that carry a $\frac{1}{2}$ -hr. supply are indicated at l . The battery is connected through the plug n . The incandescent lamp o can be used at will to make a vertical line on the film whenever the operator desires to locate any particular event. A fixed reference-line is made on the film by a beam of light reflected from the zero mirror p .

The records obtainable with this instrument are said to be good to 0.05 g up to a frequency of 30 vibrations per sec.

A SYLPHON ACCELEROMETER

An accelerometer developed under the direction of Dr. J. G. Coffin in the General Laboratories of the United States Rubber Co. utilizes hydraulic means for multiplying and transmitting to the recording element the slight motions of the inertia units. In the arrangement shown diagrammatically by Fig. 2, the masses a_1 and b_1 are adjustable along the lever arms c_1 and d_1 , the latter being pivoted at e_1 and f_1 when vertical accelerations are to be measured. The inertia effect of the masses a_1 and b_1 may be varied by changing their positions along c_1 and d_1 . With the fulcrum points at e_1 and f_1 , the slight motions of the two masses and the lever-arms to which they are attached all operate in the same direction upon the vertical spindle, extending upward from the top-cap of the flexible metallic sylphon, g_1 . The sylphon is closed at both ends and is mounted upon the base of the accelerometer. Spring h_1 keeps the system under slight initial positive pressure for the response is slower if the pressure is allowed to become negative. A flexible metal tube of small diameter connects the sylphon with the coiled Bourdon tube i_1 of the recording mechanism. The sylphon, the connecting tube and the Bourdon tube are completely filled with liquid, and the system is hermetically sealed.

By this arrangement a very slight motion of the sylphon, with the accompanying displacement of a fairly large volume of liquid, is multiplied so as to cause a relatively great motion of the Bourdon-tube recording element. The rotative motion of the latter is transmitted through a spindle to the record pen-arm j_1 , at the end of which the pen is mounted. The acceleration records are traced upon a circular paper-chart, k_1 that

is rotated by clockwork l_1 at a definite known constant speed. The speed can be set as desired by the proper choice of the governing vane m_1 .

An interesting feature of this instrument is its adaptability to the recording of either rotational or linear accelerations as desired. With the lever-arms c_1 and d_1 pivoted at e_1 and f_1 , the effects upon the masses a_1 and b_1 of all vertical accelerations combine and affect the sylphon system in the same direction. With this setting of the fulcrum points, the rotational accelerations about axes passing through the center of symmetry o_1 have no effect since they act upon the respective weights in opposite directions, the effects being thus equalized and nullified. On the other hand, in case it is desired to record the rotational effects, these may be made effective and other accelerations eliminated by removing the fulcrum-pin f_1 and placing it at n_1 . With this arrangement the effects of the linear accelerations are nullified, whereas the rotational accelerations produce a combined effect from the inertia units upon the sylphon element.

Thus, when the instrument is adjusted for accelerations at right angles to its base, it will record both the accelerations in this direction and those accelerations due to rotations about axes that do not pass through o_1 , the center of symmetry. Adjusted for rotational accelerations, the instrument will record no linear acceleration but will record all rotational accelerations whether their axes pass through o_1 or parallel to it. Linear accelerations in any direction can be measured by properly setting the fulcrum points and mounting the inertia mechanism so that the sylphon base is perpendicular to the direction of the acceleration to be measured or so that the axis of rotational oscillation passes through o_1 .

A photograph of the complete accelerometer is reproduced in Fig. 3. The operating element may be mounted at the point under investigation and the recording mechanism may be conveniently stationed in a suitable position.

THE NAVY ACCELEROMETER

One of the simplest accelerometer designs is that developed under the direction of Dr. A. F. Zahm, of the Navy Department,* in connection with a study of aircraft landing-shocks. This instrument differs materially in design from those above described. As shown by Fig. 4, it consists of a number of pointed styluses a_1 so held by helical springs of varying tensions that the recording points when at rest are only a few thousandths of an inch above a moving record-strip of treated paper, b_1 , propelled by the clockwork c_1 . Each spring is adjusted differently from its neighbors so that the styluses will respond to different degrees of acceleration. Whenever the instrument is subjected to an acceleration greater than that for which a particular stylus is adjusted, that stylus and all those below it in tension will drop and come into contact with the record-strip, with the result that corresponding dots or lines are recorded and form part of a discontinuous record of accelerations. By using a sufficiently large number of styluses, the blind intervals between the sensitive points may be suitably reduced. The instrument is not, however, adapted to the recording of small high-frequency vibrations.

SEISMOGRAPH DESIGN

The seismograph as applied to the study of vehicle motions is designed to record the time-displacement curve of the displacement of a point on the vehicle. From this curve it is possible to obtain direct information as to amplitudes and periods, and by differentiation to in-

* See *Journal of the Franklin Institute*, August, 1919, p. 237.

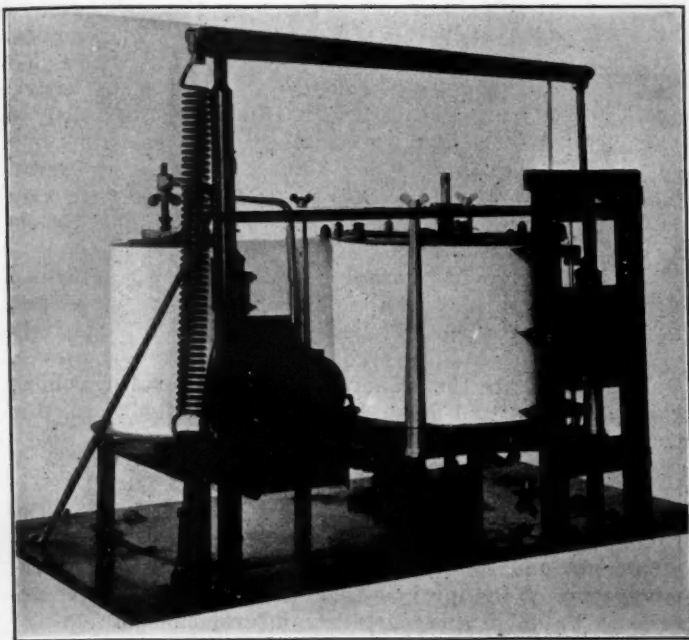


FIG. 6—SEISMOGRAPH DEVELOPED IN THE INTERNATIONAL MOTOR CO. LABORATORIES UNDER THE DIRECTION OF A. F. MASURY

The Paper Record Chart Is Rolled from the Storage Spool at the Left to the Record Spool at the Right as the Latter Is Rotated by a Flexible Drive from a Front Wheel of the Vehicle. The Seismograph Weight Moves Vertically Along Guides as the Instrument Encounters Vertical Jolts, a Pencil Attached to the Weight Records the Movement upon the Chart, while the Time Records Are Made by a Pencil Actuated from a Phonograph Motor Properly Governed

investigate the velocities and accelerations encountered.¹⁰ The differentiation may be accomplished by a more or less inaccurate and laborious process of curve-analysis or by the use of mechanical means.¹¹ The first derivative curve of the displacement-time curve is that of velocity,

¹⁰ See *Journal of the Franklin Institute*, August, 1919, p. 237.

¹¹ See *Journal of the Franklin Institute*, January, 1918, p. 119 and February, 1918, p. 269; also *THE JOURNAL*, January, 1920, p. 17.

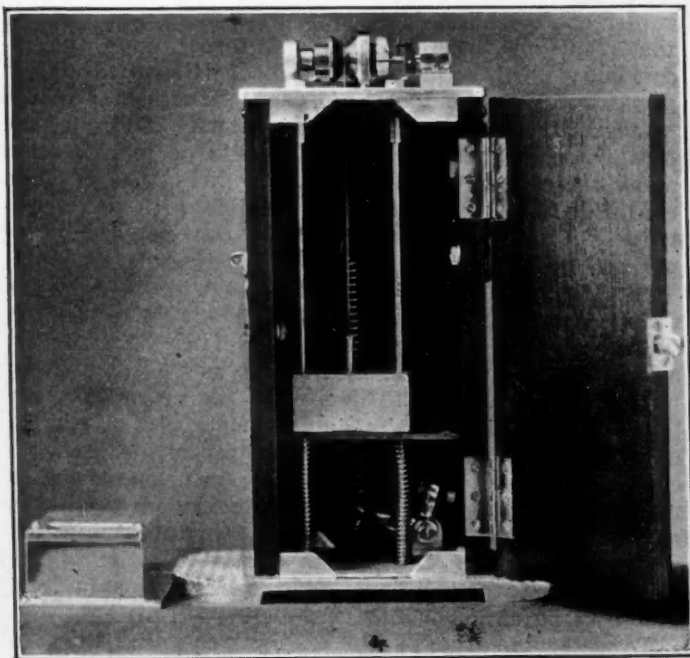


FIG. 7—INTEGRATING SEISMOGRAPH

This Instrument, Developed at Yale University under the Direction of Prof. E. H. Lockwood, Sums Up the Vertical Displacements of a Spring-Supported Inertia Element

whereas the second derivative curve is that of acceleration.

A seismograph for the measurement of vertical motions of a vehicle usually consists of an inertia element or mass balanced against a spring and attached to a recording mechanism so that motions of the instrument-base with respect to the mass are recorded upon a moving chart driven at a known constant speed. In the diagrammatic sketch of Fig. 5, the essential elements are a , the inertia element; b , the spring; c , the pen-arm, and d , the record-drum.

It is the aim to design the instrument so that the inertia element will remain vertically fixed as nearly as possible while the instrument frame partakes of the motions of the vehicle under investigation. This condition requires a relatively long natural period of vertical oscillation for the inertia element. It has been shown¹² that if the natural period of the inertia element is five times the longest period of oscillation to be recorded, the error introduced by the slight motion of the element is about 4 per cent.

The seismograph shown by Fig. 6 was developed in

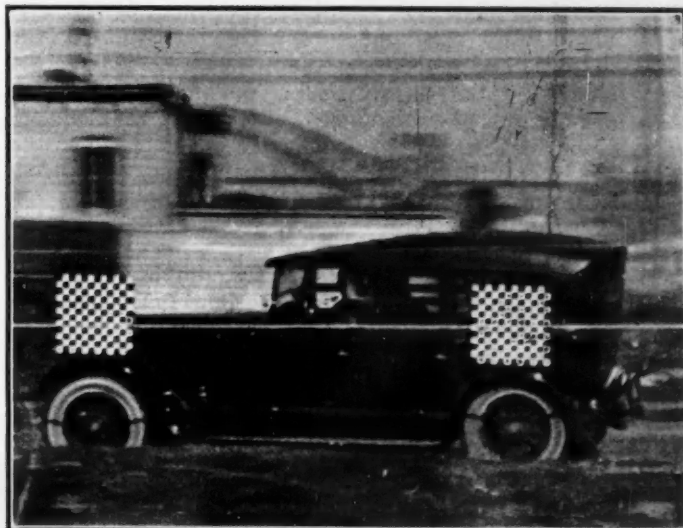


FIG. 8—PHOTOGRAPHIC RECORDING OF VEHICLE MOTIONS

This Cutting from a Motion-Picture Film Made under the Direction of H. I. Stengel, Uppercu Cadillac Corporation, New York City, Shows the Coordinate Boards Mounted upon the Vehicle and the Reference Line Photographed Against Them. Motions of the Vehicle May Be Determined by Examining the Relative Position of the Car and the Reference Line in Successive Exposures

the laboratories of the International Motor Co. under the direction of A. F. Masury. The inertia element is shown at the right between two vertical guide-rods. A pencil mounted directly upon the mass rests upon the record-chart and traces a curve as the mass oscillates. The mass is balanced through a suitable linkage against the coil-spring shown at the left. The record-drum is driven from the front wheel of the vehicle through a flexible shaft. On the upper edge of the drum is a series of cams equally spaced which trip a pencil-holder and record distances of $1/10$ or $1/320$ mile, depending on the ratio used. A phonograph motor is arranged and adjusted so as to trip a pencil that records seconds of time on the record-chart. A stationary pencil marks upon the chart a horizontal zero-line with which the inertia-element pencil coincides when the element is in its normal position of rest. Means are provided for properly damping the motions of the mass.

One investigator has combined the seismograph with an arrangement that shows, on the same chart with the

seismograph records, the relative motion of the rear axle with respect to the chassis.¹²

AN INTEGRATING SEISMOGRAPH

An instrument known as an integrating seismograph has been developed at Yale University under the direction of Prof. E. H. Lockwood. It automatically sums up the vertical displacements of a suspended weight that is mounted in a case carried on the vehicle under test. Comparisons between various cars and equipment are made by driving with the instrument over a stretch of test-road at definite known speeds. The instrument readings are affected by both the frequency and the magnitude of the impulses encountered.

Fig. 7 shows the inertia-element suspended by a spring-regulated flexible cord that passes over a pulley at the top of the case. The pulley is connected through a one-way ratchet device to a small counter so that only the upward vertical motions of the weight are registered by the counter. The weight when initially at rest is supported by a spring-table that is intended to magnify the instrument readings on rough roads. Interesting methods of calibrating the instrument and interpreting its indications have been devised.¹³

A number of experimenters have investigated the vertical motion of vehicles by mounting at various points instruments similar to the pocket pedometer. The indications represent summations of those vertical accelerations that have been sufficiently great to cause the counter to register. Whether the information thus afforded is of any great value is questionable.

PHOTOGRAPHIC METHODS

Motion-picture photography offers a simple method of studying certain types of vehicle motion.¹⁴ An arrangement frequently employed includes targets or boards of coordinates marked off in squares and properly mounted on the vehicle under test. Fig. 8 shows the installation used in tests conducted by the Upper Cadillac Corporation, New York City, under the direction of H. I. Stengel. A fixed reference-line consisting of a tape or marker stretched along the test-road at a suitable height is photographed against the moving board of coordinates as a background. Thus, a motion picture taken of the vehicle as it passes along the test-road shows progressively the vertical position of the vehicle with respect to the reference line. Artificial bumps or obstacles are usually placed in the road and the behavior of the vehicle is noted during runs at definite known speeds. It is possible to analyze the motion by means of slow-motion pictures or by the individual examination of the successive exposures. In the latter way a displacement-time curve may be plotted.

Direct photographing of lights¹⁵ mounted upon the vehicle and its load offers another simple method of analyzing motion. The traces shown by Fig. 9 were obtained under the direction of Prof. W. E. Lay, of the University of Michigan, by photographing at night with a special wide-angle camera a series of four incandescent lamps mounted upon a fully-loaded truck that passed over a $3\frac{7}{8}$ -in. bump at a speed of 10 m.p.h. The truck was equipped with artillery wood wheels and pneumatic tires. The five traces in Fig. 9, reading from the bottom up, represent respectively the base-line made by rolling by hand over the course a wooden wheel equipped at its center with an incandescent lamp, the center-line

of the front axle, the front of the body, the center-line of the rear axle, and the rear of the body. The vertical height-scale may be obtained from the bottom trace that shows clearly the $3\frac{7}{8}$ -in. obstruction. The horizontal scale of time was obtained in the tests by referring to the known velocity and to the wheelbase of the truck in a photograph that showed the vehicle as well as the curves. These curves of vertical displacement against time may be analyzed with respect to vertical velocities and accelerations by differentiation.

Obviously, the photographic methods above described do not yield results of the highest order of precision, nor are they useful in the investigation of relatively slight motions at high frequency. They are, however, well adapted to the general study of certain vehicle characteristics and have been used effectively in this connection.

PROPOSED RESEARCH

It is believed that instrument designers have the fundamental knowledge necessary for constructing instruments and developing methods adequate to the investigation of the motions that prevail in automotive vehicles. Valuable and pertinent information can be obtained by the use of devices similar to those described in the previous paragraphs. But what does an accelerometer or seismograph record mean in terms of comfort?

This is clearly the outstanding phase of the general problem that needs most careful study. If it were possible to appraise the effects of particular types of motion as regards their importance with respect to fatigue or discomfort and to establish the responsibility for these motions at the proper points, it would be a much simpler matter to effect improvements. The individual sources contributing to the difficulty could be dealt with separately and collectively in such a way as ultimately to bring about a harmonious combination.

It seems, therefore, that the aim of riding-quality research should be: first, to analyze accurately the motions and forces to which an automobile passenger is subjected; second, to determine as definitely as possible the effects of these motions and forces upon the individual; third, to correlate the conditions with their proper sources, and fourth, to remedy the causes of the uncomfortable or fatiguing conditions. This is admittedly a large task, but the results of investigation along these lines would undoubtedly bring the problem nearer to its solution than is possible with an unsystematic attack upon various phases considered individually.

A certain amount of study has been devoted to the characteristics of vehicle motions, chiefly in connection with the investigation of springing. There is, however, a lack of coordination in the results, as well as a great need of further study to determine the magnitude, the frequency and the exact type of the motions that may be expected to occur. The vertical displacements have received particular attention to the exclusion of other motions along and around the principal axes. It is suggested that further work be done in this connection with an instrument installation that will record simultaneously both the rotational and the translational effects that may be of importance.

To determine the effects of the prevailing motions upon the average individual is a difficult problem of which very meager study has been made. It seems that such a determination would be possible of accomplishment if the proper agencies concentrated on the problem.

¹² See THE JOURNAL, December, 1923, p. 445.

¹³ See THE JOURNAL, July, 1924, p. 40.

¹⁴ See THE JOURNAL, July, 1920, p. 96.

¹⁵ See THE JOURNAL, December, 1917, p. 376.

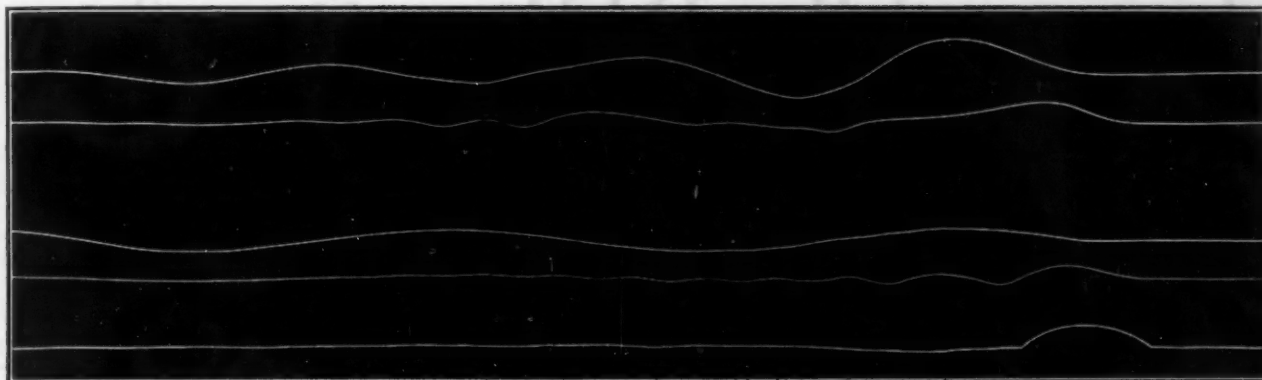


FIG. 9—PHOTOGRAPHIC TRACES MADE BY INCANDESCENT LAMPS MOUNTED ON A TRUCK UNDER TEST TO DETERMINE RIDING CHARACTERISTICS

The Traces Reading from the Bottom Up Are Respectively the Base-Line Made by Rolling a Wooden Wheel, Equipped with a Lamp at Its Center, over the Course; the Path Followed by the Center Line of the Front Axle; the Path of the Front Part of the Body; the Path Followed by the Center Line of the Rear Axle; and the Path of the Rear Part of the Body. The Tests in Which This Chart Was Obtained Were Conducted under the Direction of Prof. W. E. Lay, of the University of Michigan

Necessarily, there are perfectly definite reactions within the human organism that cause or accompany nervous, mental and physical fatigue. Is there not a possibility of correlating these reactions with their causes? In this connection it has been suggested by a number of investigators that valuable information might be obtained by subjecting a large number of individuals to laboratory tests in which riding conditions could be accurately reproduced with suitable apparatus. In close cooperation with physiological and psychological experts, it should be possible to obtain definite clues to the effect of well-defined motions or combinations of motions upon the average individual. This work, of course, presupposes a knowledge of the riding conditions that should be reproduced.

Assuming that the above-stated relations were established, the information would be of little practical value unless it could be applied to the investigation of the in-

fluence upon the motions of the various components of the vehicle. In other words, before a cure could be effected by improved design, it would be necessary to determine the points most needing improvement. It is believed that the final steps in the procedure outlined above would promptly follow the discovery of the true relations between motions and other phenomena with respect to the passengers' comfort.

It is well understood that the procedure outlined above may be considered by some to be more or less visionary and impractical. It is firmly believed, nevertheless, that research properly directed along these lines would bear fruit that would amply justify the necessary expenditure of time and effort.

The author gratefully acknowledges his indebtedness to E. H. Bailey and U. Delchamps who were of assistance to him particularly in the work of compiling the references to the different articles mentioned.

NATIONAL WEALTH

ONE of the most impressive economic phenomena of the war and post-war period in the United States, as everywhere else in the world, has been an extensive change in the prices, or money valuations, of almost all kinds of property. Owing to this extensive change of the price level, great increases in the money value of given forms of property which took place between 1912 and 1922 are very far indeed from signifying corresponding increases in the quantity or quantities of such property; that is, corresponding increases in real wealth as distinguished from mere money wealth. The Census Bureau has carefully called attention to this extremely important economic fact, saying that

It should be borne in mind that the increases in money value are to a large extent due to the rise in prices which has taken place in recent years and, so far as that is the case, they do not represent corresponding increases in the quantity of wealth.

The real wealth of the American people consists, of course, of the quantities of the various kinds of actual property it possesses, irrespective of the money value of these quantities of property.

Good economic reasons exist for thinking that this Country

did not suffer the tremendous losses and wastes incident to the European War without an actual decrease, rather than an increase, of the quantity of its real per capita wealth.

The money value of the motor vehicles in the United States in 1922 is put by the Census Bureau at \$4,567,407,000. The first reflection of the economist upon perusing the figures for the different categories of our national wealth in 1922 and comparing these figures with the corresponding figures for 1912 will perhaps be that we now have a convincing statistical picture of the manner in which the great price-changes brought about by the war have chiefly inured to the benefit of the industrial and urban classes of the population. Thus we have a gain of 159.1 per cent in the money value of the machinery and equipment of the manufacturing industries, though it is very doubtful whether the increase in the physical quantity of such machinery and equipment was as much as 50 per cent. On the other hand, we have a decrease of 6.9 per cent in the money value of the Country's live stock, though the number of our farm animals other than sheep was approximately the same in 1922 as in 1912. Other comparisons tend to the same conclusion.—A. R. Marsh in *Economic World*.

Automobile Riding-Comfort

By S. P. HESS¹

SEMI-ANNUAL MEETING PAPER

Illustrated with DRAWINGS AND PHOTOGRAPHS

RIDING-COMFORT is defined as the transportation of an automobile passenger in so easy a manner that the trip will be a pleasure and not a hardship. Since spring-suspension constitutes the basis of riding comfort in passenger-cars, the paper deals with some of the important factors that determine correct chassis spring-suspension. An analysis made by the National Automobile Chamber of Commerce of replies received to a questionnaire it circulated among 20,000 car-owners is presented in proof of the genuine interest the motoring public has in the riding-quality of a car, and the variable factors that have an influence on spring-suspension are stated to be the type of spring used, its physical dimensions, the amounts of sprung and unsprung weight, frame construction, wheelbase dimension and the kind of material used.

Horizontal, vertical and sidewise motions of a car are analyzed, and a periodicity chart is shown for passenger cars of from 112 to 116-in. wheelbase. Since periodicity is a function of deflection, the derivation of the number of vibrations per minute is explained and the reduction of vertical motion is discussed.

A periodicity machine designed to determine the value of inter-leaf friction as a damping medium is illustrated and described, and the results obtained from tests are stated. Sidewise motion and the effects of balloon tires and four-wheel brakes on riding-quality are treated briefly.

SPRING-SUSPENSION is the basis of riding-comfort in passenger cars, and this paper concerns itself with some of the important factors that determine correct chassis spring-suspension. Other mechanical features of a car exist which, supplementing and modifying the action of the springs, help to eliminate driving fatigue. These are cushion springs, rubber shackles, shock-absorbers and balloon tires. Since these are subjects that others may treat at length, I shall touch on them only as they affect chassis spring-design.

TABLE 1—RESULTS OF SURVEY AMONG 20,000 CAR-OWNERS OBTAINED BY THE NATIONAL AUTOMOBILE CHAMBER OF COMMERCE

	Per Cent
Endurance	15.0
Economy of Operation	14.0
Comfort	9.5
Price	9.5
Appearance	8.0
Service, Good Local Repair-Shops	7.5
Hill-Climbing Ability	7.0
Flexibility	6.5
Endorsements; Opinions of Other Car-Owners	6.5
Specifications	5.5
Appointments	5.0

That the general motoring public has a genuinely vital interest in the riding-qualities of a passenger-car is convincingly shown by the results of the recent investigation conducted among car-owners by the National Automobile Chamber of Commerce. The analysis of the answers it obtained is shown in Table 1.

Only one interpretation of the term "riding-comfort"

¹ M.S.A.E.—Assistant manager, spring department, Detroit Steel Products Co., Detroit.

can be made. It means the transportation of a passenger in so easy a manner that the trip will be a pleasure and not a hardship. The ride may be over good, bad or indifferent roads, at any rate of speed and under so many conditions of passenger loading that it is practically impossible to meet all conditions of comfort through chassis springs alone. Even when all mechanical means have been taken to obtain good riding-quality for a car, the human or psychological element and the fact that some particular motion of a car may be decidedly objectionable to one person and yet be unnoticed by another still remain. The tendency of many people not to relax when riding also induces fatigue, even in cars in which every precaution has been taken to provide riding-comfort. Care must be taken to shape the backs of seats to provide for the passengers' comfort, in addition to using cushion springs of the correct stiffness.

Regarding chassis spring-suspension, experience has taught us that, in the study of riding-comfort, each design of motor car must be considered individually. Certain variables are present in each instance and their influences upon spring-suspension is given below.

- (1) *Type*.—The semi-elliptic and the cantilever types, either semi-elliptic or quarter-elliptic, are the two in general use
- (2) *Physical Dimensions*.—Length and width regulate the flexibility that can be obtained with stresses conducive to long life
- (3) *Sprung and Unsprung Weights*.—These determine the flexibility and influence on the presence of rebound
- (4) *Frame Construction*.—A rigid frame-construction requires more flexible springs because the frame has practically no "give" to road shocks. This is reversed on frames of less rigid construction
- (5) *Wheelbase*.—This influences the flexibility to provide for balance between front and rear springs
- (6) *Material*.—The kind of material regulates the flexibility that can be obtained with stresses conducive to long life

MAJOR DIRECTIONS OF CAR MOTION

Three major directions of motion exist, and these must be considered in suspending a motor vehicle. Their relations are shown in Fig. 1. The motions are the horizontal or pitching motion a_h , the vertical or up-and-down motion a_v and the sidewise or swaying motion a_s . Because these motions cannot be eliminated, the solution lies in the reduction of their magnitude.

The ideal condition, of course, would be that in which the floor of the motor car would be always at the same level, without vertical motion, similar to that of a Pullman coach riding smoothly over the rails. But since road contours are varied and speed continually changes, it is impossible to design springs that will absorb energy and at the same time dissipate it fast or slowly enough to accommodate the rapidly changing road contour. Therefore the attainment of this ideal condition is still

in the future. Shock-absorbers have done much in ironing out the ridges in rough roads by slowing-up the action of the spring or reducing the intensity of the deflection or the rebound.

Horizontal or pitching motion can be attributed to acceleration or deceleration of the motor car. This may be the result of increasing or decreasing the speed through the power of the engine, or it may be due to some obstacle or depression in the road. This may be almost wholly corrected by having the proper balance

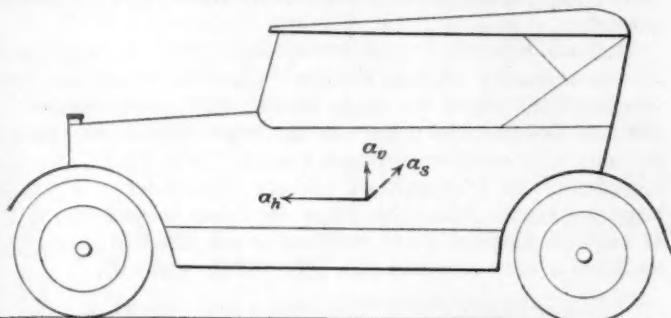


FIG. 1—THE THREE MAJOR DIRECTIONS OF MOTION THAT MUST BE CONSIDERED IN SUSPENDING A MOTOR VEHICLE

While the Ideal Condition Would Be the Complete Elimination of These Motions, This Cannot Be Attained and the Solution of the Problem Lies in the Reduction of Their Magnitude

between the flexibility of the front spring and the flexibility of the rear spring. For a car of from 112 to 116-in. wheelbase, having flexibilities approximating 140

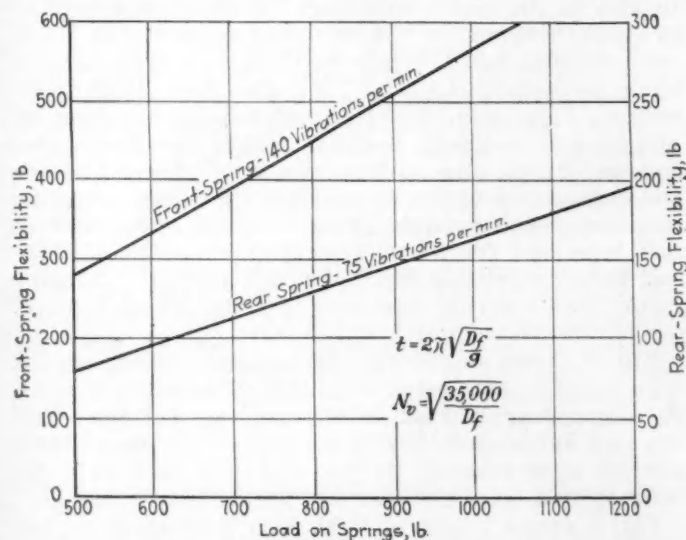


FIG. 2—PERIODICITY CHART FOR PASSENGER CARS HAVING A WHEEL-BASE OF FROM 112 TO 116 IN.

These Cars Are Assumed To Be Equipped with Standard Pneumatic Tires and To Have No Shock-Absorbers. The Point of Intersection of the Load Value with the Spring Curve Gives the Flexibility as Indicated by the Ordinates

vibrations in front and 75 vibrations in the rear, very good riding-comfort is obtained.

Fig. 2 is a periodicity chart for passenger-cars of from 112 to 116-in. wheelbase, without shock-absorber and equipped with standard tires. For full passenger-load on the spring, plotted as abscissas, the corresponding flexibility is traced on the ordinates. Periodicity is a function of deflection, and the number of vibrations per minute is derived as follows:

D_f = Deflection in feet

D_i = Deflection in inches = $D_f/12$

g = Acceleration due to gravity = 32.16

N_v = Number of vibrations per minute = $60/t$

t = Time in seconds

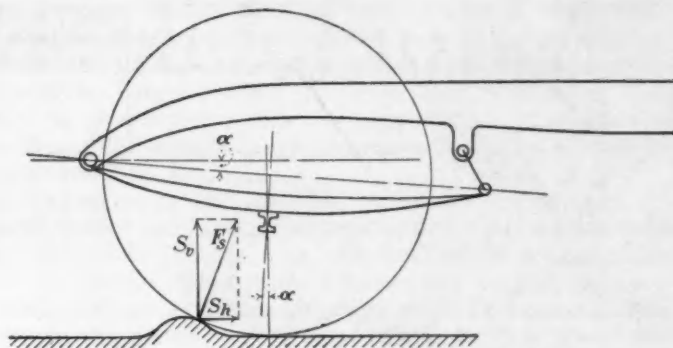


FIG. 3—METHOD OF SUSPENDING THE FRONT SPRING TO RESIST ROAD SHOCKS

The Horizontal Component of the Road Shock S_h Should Be as Small as Conditions Will Permit Since It Reacts Directly on the Front Spring-Bolt, Causing Considerable Wear, and Puts a Very Unpleasant Reaction on the Frame

where

$$t = 2\pi \sqrt{(D_f/g)} \quad (1)$$

$$W_v = 60/t = \sqrt{(35,500/D_i)} \quad (2)$$

For cars of less than 112-in. wheelbase the ratio increases. For cars of more than 116-in wheelbase the

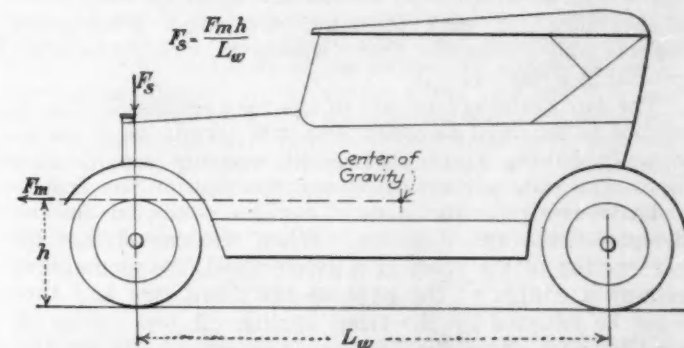


FIG. 4—DIAGRAM SHOWING HOW EXCESSIVE PITCHING MOTION CAN BE CORRECTED BY THE PROPER DESIGN OF A FRONT SPRING

When the Car Strikes an Obstruction in the Road, at a Given Speed, the Momentum Sets-Up a Couple at the Point of Contact between the Front Tire and the Ground, Which Must Be Resisted by the Front Spring. A Low Center of Gravity Will Decrease the Couple and Also Reduce the Resistance Required of the Front Spring

ratio decreases and approaches unity in the case of an imaginary long wheelbase.

A forward "caster" of the front axle and a corre-

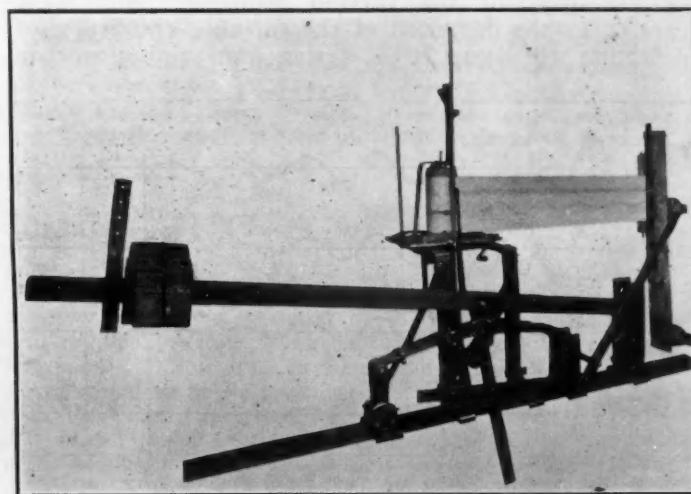


FIG. 5—PERIODICITY MACHINE CONSTRUCTED TO DETERMINE THE VALUE OF INTERLEAF FRICTION AS A DAMPENING MEDIUM
The Vertical Movement of the Spring Resulting from the Placing of Weights on the End of the Lever Was Traced on a Strip of Paper 10 Ft. Long Which Passed over Two Rollers

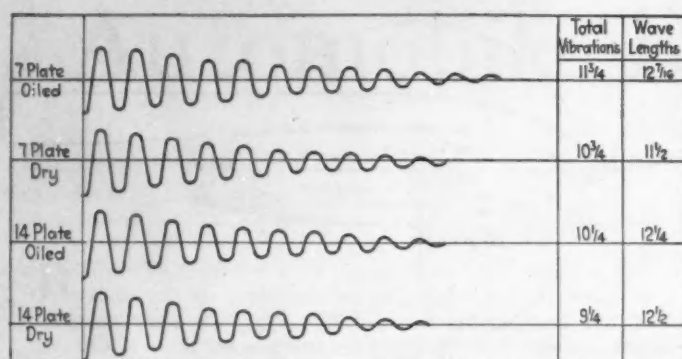


FIG. 6—RESULTS OF TESTS ON TWO FRONT SPRINGS WITH A DEAD LOAD OF 400 LB.

These Springs Were 2 In. Wide and 36 3/4 In. Long. One Spring Had 7 and the Other 14 Leaves. Both Springs Were Tested in an Oiled and a Dry Condition by Deflecting Them 2 1/2 In. and Then Releasing Them. The 7-Leaf Spring Had a Flexibility of 427 Lb. and Weighed 28 Lb.; the 14-Leaf Spring Had a Flexibility of 455 Lb. and Weighed 39.8 Lb.

sponding tilting of the front springs serve as a means of absorbing the horizontal component of the average road-shock. From experience, 2 1/2 deg. has proved to be the angle at which road shocks are absorbed very well; it provides for easy steering, eliminates front-wheel wobble and allows the front wheels to straighten after rounding a corner.

The horizontal component of the road shocks S_h , Fig. 3, should be as small as conditions will permit, as it reacts directly on the front spring-bolt, causing considerable wear, and puts a very unpleasant reaction on the frame.

Excessive pitching motion can be corrected in the design of the front spring. When the car strikes an obstruction in the road, at a given speed, the momentum sets-up a couple at the base of the front tire and this must be resisted by the front spring. A low center of gravity will naturally decrease the magnitude of the couple, and also reduce the resistance required of the front spring. Fig. 4 shows that $F_m h = F_s L_w$, in which

F_m = Momentum

F_s = Force on the front spring

h = Height of the center of gravity above the ground

L_w = Length of the wheelbase in inches

REDUCTION OF VERTICAL MOTION

Vertical, or up-and-down, motion may include rebound or the part of the vertical component not taken care of by the deflection of the spring. Practically no deflection will occur in the spring when riding over an

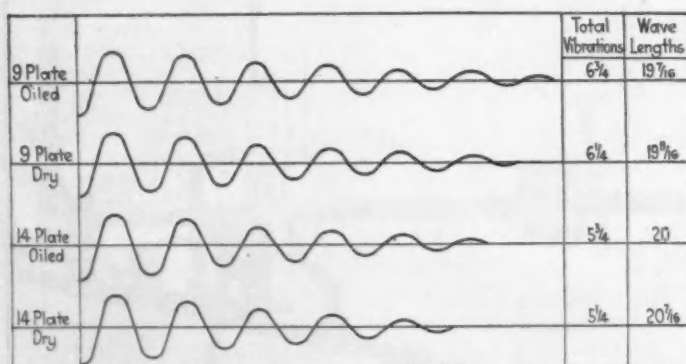


FIG. 7—RESULTS OF TESTS ON TWO REAR SPRINGS WITH A DEAD LOAD OF 400 LB.

These Springs Were 2 In. Wide and 54 In. Long, One Spring Having 9 and the Other 14 Leaves. Both Springs Were Tested in a Dry and an Oiled Condition by Deflecting Them 3 3/4 In. and Then Releasing Them. The 9-Leaf Spring Had a Flexibility of 144 Lb. and Weighed 43 Lb.; the 14-Leaf Spring Had a Flexibility of 145 Lb. and Weighed 54.4 Lb.

obstruction at slow speed; the body of the car at that point will be lifted to the height of the obstruction. At high speed, the impact will deflect the spring, storing up a certain amount of energy. The manner in which the spring dissipates the energy governs the intensity and amount of rebound transmitted to the frame. A flat spring, together with inter-leaf friction, will reduce rebound because of its damping qualities, giving a semi-shock absorbing effect. To obtain the full benefit of inter-leaf friction, springs should not be lubricated between the leaves, unless used with some type of shock-absorber.

Balloon tires and cushion springs play an important rôle in reducing vertical motion. Consider a specific road obstruction, taken at high speed; the low-pressure or balloon tire absorbs a part of the road shock, the chassis springs and cushion springs absorb their share and the remainder is transmitted to the passenger. This all happens faster than the time required to tell about it. If vertical motion is not reduced or modified in intensity, we have a very disagreeable rebound as a result.

DETERMINATION OF INTER-LEAF FRICTION

We built a periodicity machine, shown in Fig. 5, to determine the value of inter-leaf friction as a damping medium. We used 10 ft. of paper on two rollers on which to trace the vertical movement of the spring. All levers and bearings were well lubricated. The springs used for experiment were designed with the same total "nip" or pull between the leaves, resulting in the same tension in the center-bolts and the same total bearing-pressure between the leaves. The ends of the leaves were rounded and the rebound-clips were free, to eliminate mechanical friction. We used two 37-in. front springs, 7-leaf and 14-leaf respectively, each having approximately a 450-lb. flexibility; also, two 54-in. rear springs, 9-leaf and 14-leaf respectively, each having approximately a 145-lb. flexibility. The results obtained, with a superposed weight of 400 lb. at the center, showed that inter-leaf friction is desirable; also, that a multi-leaf spring of similar flexibility has a greater damping factor than a spring composed of fewer leaves, because the former has greater frictional area.

Fig. 6 shows graphically the results obtained on the front springs, both when oiled and when dry. The 14-leaf dry-spring damped in 9 1/4 periods and the 7-leaf oiled-spring damped in 11 3/4 periods. This represents a gain of approximately 27 per cent. In each case the front springs were deflected 2 1/2 in. and then released.

Fig. 7 shows graphically the results obtained on the rear springs, both when oiled and when dry. The 14-leaf dry-spring damped in 5 1/4 periods and the 9-leaf oiled-spring damped in 6 3/4 periods. This represents a gain of approximately 28.5 per cent. In each case the rear springs were deflected 3 3/4 in. and then released.

SIDEWISE MOTION

Sidewise, or swaying, motion is due primarily to centrifugal force when rounding corners or curves at high speed. A low center of gravity of the body, wide spring-centers, flat springs and shackles designed to resist side-pressure practically will eliminate this disagreeable motion. Swaying motion is increased, to some extent, by balloon tires and, for this reason, the center of gravity must be low. At 50, and more, m.p.h., the cars equipped with the larger-section tires, the 6-in. and the 7-in. sizes, seem to cause considerable side-swaying, as if the car were unsteady on its four "legs," and the driver has a sensation of losing control of the steering. For this

reason, although this occurs at high speeds, I believe cars should be equipped with tires of less than 6-in. section so long as we have the benefit of low pressure.

FOUR-WHEEL BRAKE AND BALLOON-TIRE EFFECTS

Very little change is necessary on front springs when used with four-wheel brakes. The springs should be flat under load and clipped properly to reduce the fanning of the leaves in the front when the brakes are applied.

Cars equipped with balloon tires require front and rear springs of increased stiffness. Fundamentally, we could shorten the front and the rear springs a trifle on account of the decreased deflection and consequent lower stresses, or we could use the same lengths of spring as at present but with heavier gages of steel. However, such a change is difficult to make because only a few makes of

car include balloon tires as their standard equipment.

Riding-comfort depends also on permitting the springs to function without restraint. This does not include the desirable damping-effect of inter-leaf friction or the action obtained through the application of shock-absorbers. Shackle-bolts and shackles must be lubricated thoroughly at all times.

Making your car one that will have better than an even chance when comparisons are made with other cars of the quality of the ride afforded, requires that there be the closest cooperation between the spring engineer and your own engineer when the model is planned. The spring-engineer's experience, added to the plant engineer's requirements, will result in producing the best spring-suspension, one that utilizes the best material and has the longest life consistent with riding-comfort.

THE UNITED STATES AS A PRODUCER

THE United States wheat crop constitutes over one-fourth of all the wheat grown. Its corn crop is three-quarters of the world corn crop, and it produces about three-fifths of all the cotton. Although the normal wool consumption of American mills is more than twice the domestic wool production, the wool clip in the United States is about one-half that of Australia, the foremost producer. The annual coal output is equivalent to the combined output of Germany, Great Britain and France, the three next largest producers; and its yearly output of iron ore is well over 50 per cent of all the iron ore mined.

The United States produces about two-thirds of the world's petroleum and it is foremost as a producer of copper, lead and zinc, as well as of forest products. This Country takes an unimportant place only in the production of some of the less common minerals, such as tin, nickel, asbestos and diamonds; in the production of those classes of agricultural products for which it is relatively unsuited climatically, as cane sugar and rubber; and in those lines where cheap agricultural labor is essential, raw silk and tea being typical of the latter class.

The United States took first place in the iron and steel industry about 1890; now its annual product is in excess of the combined output of the United Kingdom, Germany, France and Belgium. It became the foremost consumer of raw cotton in the closing years of the 19th century, taking the leadership from the United Kingdom, which had theretofore been the largest user. Due to the fact that the proportion of fine counts spun in Great Britain is higher than in the United States, British yardage at capacity is still in excess of that of American mills, but it is not believed that this precedence can be long maintained.

Until the World War, the United Kingdom was definitely the leader in the woolen and worsted industries of the world.

During the war period American raw wool consumption and production of fabrics expanded rapidly and it is probable that now the capacity of the industries of the two countries from the standpoint of wool consumption is not materially different. The United States now uses one-third of the world's cotton, one-fourth of the commercial supply of wool, about three-fifths of all the copper mined and the iron ore produced, two-thirds of the annual raw silk crop entering into commerce and from two-thirds to four-fifths of the raw rubber grown. Despite the enormous volume of American manufactures, this Country is not foremost as an exporter of industrial products except in special lines. Great Britain still holds first place in export trade in manufactured articles.

TRANSPORTATION

The history of the United States is the history of modern transportation. The remarkable expansion of the country is in part the result of the building of railroads, but in turn American railroad transportation is the result of the fact that so great was the potential wealth of the United States that it became profitable to carry railroads across a half-settled continent. These railroads made the United States a nation, and they gave its people a continental outlook and a national unity.

When due consideration is given to quality of land, adequacy of rainfall, and wide range of climate and consequently of products, coupled with suitability as a habitat for the white race, North America is the richest area of the world.

Two-thirds of all the raw silk of the world is now consumed by American mills. The silk makers of this Country now turn out as fine products as the world has seen, excepting for the very limited output in certain places of what practically amounts to a hand industry.—*Commerce Monthly*.

THE FARMERS' DIFFICULTIES

THE farmers' present difficulties grow primarily out of the fact that agriculture, relative to manufacturing, is an over-expanded industry, and this is particularly true of grain and live stock. Europe, which before the war was the manufacturing center of the world and the world's chief market for farm products, has so greatly reduced its ability to produce and export manufactured goods and its consequent ability to pay for farm products, that the balance has been broken, and agriculture, not only in the United States but also in Canada, in the Argentine and in virtually every other part of the world, is suffering as a consequence. Prices of manufactured goods are excessively high owing to the scarcity of manufacturing activity; and the prices of farm products, grain and live stock are relatively very low as a

consequence of the relative excess of agricultural production. The balance will be restored by increasing manufacturing activity, or by reducing agricultural activity, or by both. The most desirable way in which the balance could be restored would be by an early restoration of Europe. Failing that, the balance can only be restored by the much slower and more painful process of the abandonment of the least profitable agricultural production, the partial shifting of agricultural production from the least profitable lines, such as wheat and live stock, to more profitable lines, such as dairying, market gardening and the like, and the movement of population from the country to the city. This process is now going on undetr the influence of the great discrepancy in prices.—B. M. Anderson, Chase National Bank.

A Mechanical Continuous-Torque Variable-Speed Transmission

By EDWARD B. STURGES¹

SEMI-ANNUAL MEETING PAPER

Illustrated with DRAWINGS AND PHOTOGRAPHS

POWER-TRANSMISSION devices may be classified into two general groups: those having intermittent or step speed-changes and those having contiguous or curve speed-changes. The increasing demand for a positive variable-speed power transmission, particularly since the introduction of the internal-combustion engine, which has very limited flexibility, has resulted in the development of the step speed-transmission unit to the limit of its practical possibilities. The difficulties of the conventional gearset have led to the invention of many devices for transmitting as nearly as possible the changes of an infinite number of speed-ratios between the driving and the driven members. Although the number of speed changes that may be obtained with the friction type of transmission is infinite, the changes are nevertheless of the step type and are not positive. A serious handicap also is the fact that the torque radius of the driving member is inversely proportional to the torque of the driven member.

To overcome these difficulties, the variable-speed power transmission described in the paper has been designed. This consists primarily of a nutating power-transmitting body called the mutor, inclosed in and concentric with a metallic sphere. The nutating body or mutor is equipped with clutch elements that co-operate with the inside surface of the sphere, the transmission being designed so that the relative angular axial positions of the mutor and the sphere may be varied, the mutor nutated and the rotation transmitted from it. Power is transmitted from the driving to the driven member through the mutor which, receiving its movement of nutation from the driver, acquires from it a continuous movement of rotation about its own axis and transmits it to the driven member.

Among the salient characteristics of the system are said to be the following: It is highly efficient and not subject to great wear, is positive in transmission for all speed-ratios and for all loads, and maintains constant uninterrupted action during all speed variations; the torque does not react on the speed-control mechanism; the torque-radius of the driving and that of the driven element are equal and remain constant at all speed-variations; the torque capacity increases approximately as the cube of the diameter of the transmission; in the zero position the driven element is at rest and is locked against rotation in either direction, without angular reaction on the driving element or upon the control, regardless of the speed of the driving-shaft; and contiguous or curve speed-changes are possible at speeds varying from zero to the maximum. Through these characteristics the way is opened to automatic torque-control through a torque governor that produces the proper reduction-ratio automatically through torque-reaction on the speed-controlling member.

A brief general discussion is given of the kinematics of the subject and is followed by detailed descriptions of the single-sphere heavy-duty-type transmission and the medium-duty type. Views of several types that have been tried out in automobile service are shown.

Among the advantages claimed for this transmission system as applied to automobile use are simplicity of control; greater safety; superior flexibility in starting and greater speed for the same engine horsepower in climbing hills; economy of fuel through ability to use a higher gear-ratio in the rear axle, hence, giving greater car-speeds without causing the engine to race, and incidentally adding to the comfort of passengers; possibility of the use of a lighter engine, because of the ability to produce infinite speed-reduction and therefore infinite leverage; capacity to climb any hill within the friction-coefficient of the wheels to the road; and the fact that the horsepower capacity to which the transmission can be built has no limit.

VARIABLE-SPEED power transmissions, as the name implies, are devices for transmitting power from the driving-shaft to the driven shaft of a machine at variable speeds of rotation, the driving-shaft running normally at constant speed, while the driven shaft can be run at various speeds and controlled either manually, or automatically by a speed or torque governor.

Variable-speed power transmissions may be divided, as to their essential differences in bringing about successive speed-changes, into two well-defined types: (a) transmissions with intermittent or step speed-changes and (b) transmissions with contiguous or curve speed-changes. Step speed-change devices are those in which the communication between the driving and the driven members is wholly or partly severed while the speed changes are effected, such as the geared and the friction transmissions, while curve speed devices require no disengagement.

Hydraulic and electric transmissions are not classed as mechanical. They have a wide field of application in power distribution rather than in direct power-transmission units of the kind under consideration.

OBJECTIONS TO EXISTING TYPES

The difficulties encountered in use and the limitations of the conventional gearset are well known and have led to the creation of innumerable devices to avoid the inherent difficulties of step speed-changes and to approximate as nearly as possible the advantages of an infinite number of speed-ratios between driving and driven members. The friction type of variable-speed power-transmission is characteristically non-positive; the power is transmitted from the driving to the driven member generally by single-point or line contact of smooth surfaces having high coefficients of friction. Although an infinite number of speed variations are possible in this type, they are, nevertheless, step speed-changes.

Though intermittent or step action, as a result of the necessary separation of the driving and the driven members preceding the shifting action, is one of the objectionable features of such drives, a serious handicap of the conventional friction-drive lies in the fact that the torque

¹ Secretary and treasurer, Weiss Engineering Corporation, Newark, N. J.

radius of the driver is inversely proportional to the torque of the driven member. We have here the application of the maximum torque of the driven member at the minimum torque-radius of the driver at the point of contact, with inevitable slippage as a result. This objection applies to all the numerous modifications of the friction drive, as the driven shaft cannot be brought down satisfactorily to the positions of very low speed and very high torque.

The increasing demand for a positive variable-speed

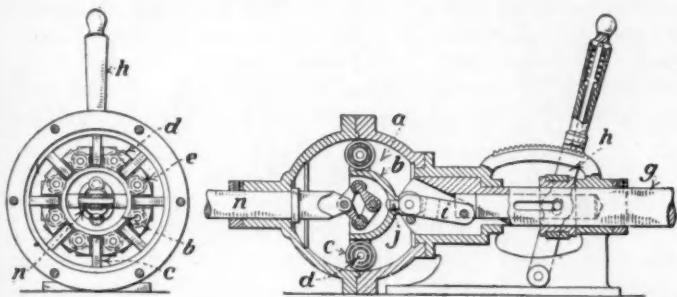


FIG. 1—END ELEVATION, PARTLY IN SECTION, AND A LONGITUDINAL SECTION OF A SINGLE-SPHERE HEAVY-DUTY TYPE TRANSMISSION

The essential element of this transmission is a nutating power transmitting body, *b*, enclosed in and concentric with the metallic sphere *a* and equipped with clutch elements that cooperate with the inner surface of the sphere. The transmission is designed so that the relative angular axial positions of the motor and the sphere can be varied, the former nutated and rotation transmitted therefrom. Power is transmitted from the driver to the driven member through the motor that, receiving its movement of nutation from the driver, rotates continuously about its own axis and transmits this movement to the driven member.

power-transmission, in general, and particularly since the introduction of the internal-combustion engine, has resulted in the development of the step speed-transmission unit to the practical limit of its mechanical possibilities. The limited flexibility of gasoline engines has excluded them from direct connection in all variable-speed power installations. The alternatives have generally been the use of a variable-speed transmission or of a steam engine.

GENERAL CHARACTERISTICS OF THE WEISS TRANSMISSION

The Weiss power transmission, an invention of Carl W. Weiss of the Weiss Engineering Corporation, Newark, N. J., is a simple and compact mechanical device for obtaining an infinite number of speed-ratios between the driving and the driven shafts from the maximum to zero without gear-shifting and without the use of a clutch. It is highly efficient and is not subject to great wear, as all the power is transmitted through ball bearings of which the efficiency and durability are well known. It is positive in its transmission of power for all speed-ratios and for all loads. It maintains constant uninterrupted action during all speed variations, for the driven and the driving elements are in constant contact.

The torque does not react on the speed-control mechanism. The torque-radius of the driver and that of the driven element are equal and remain constant at all speed variations. The torque-capacity increases approximately as the cube of the diameter of the transmission. In the zero position, the driven element is at rest and is locked against rotation in either direction without angular reaction on the driving element or upon the control, regardless of the speed of the driving-shaft.

This transmission makes possible contiguous or curve speed-changes, the speeds varying from zero to the maximum, which fact gives it a great advantage over both gear and friction transmissions.

The foregoing characteristics open the way to auto-

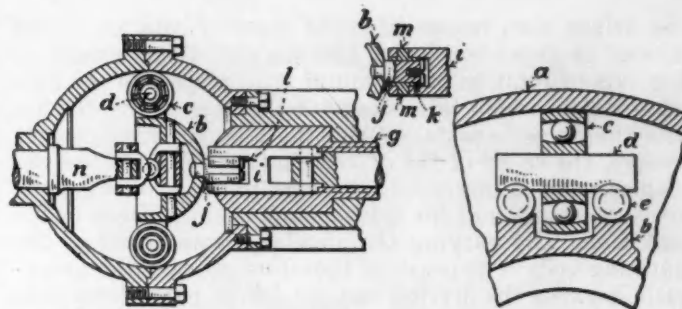


FIG. 2—VIEW SHOWING DETAILS OF MOTOR CONSTRUCTION
The Views at the Left Show the Construction Employed for the Motor Pin, While That at the Right Illustrates the Mounting of a Motor Bearing

matic torque-control through the use of what may be termed a torque-governor. The proper reduction-ratio is then obtained automatically through torque reaction on the speed-controlling member.

GENERAL DESCRIPTION OF THE HEAVY-DUTY TYPE

This form of transmission consists primarily of a nutating power-transmitting body, which we may call a motor, enclosed in and concentric with a metallic sphere. The nutating body or motor is equipped with clutch elements that cooperate with the inside surface of the sphere. The transmission is designed so that the relative angular axial positions of the motor and the sphere may be varied, the motor nutated and the rotation transmitted from it. Power is transmitted from the driver to the driven member through the motor which, receiving its movement of nutation from the driver, acquires a continuous movement of rotation about its own axis and transmits it to the driven member.

The speed of rotation of the nutating motor and of

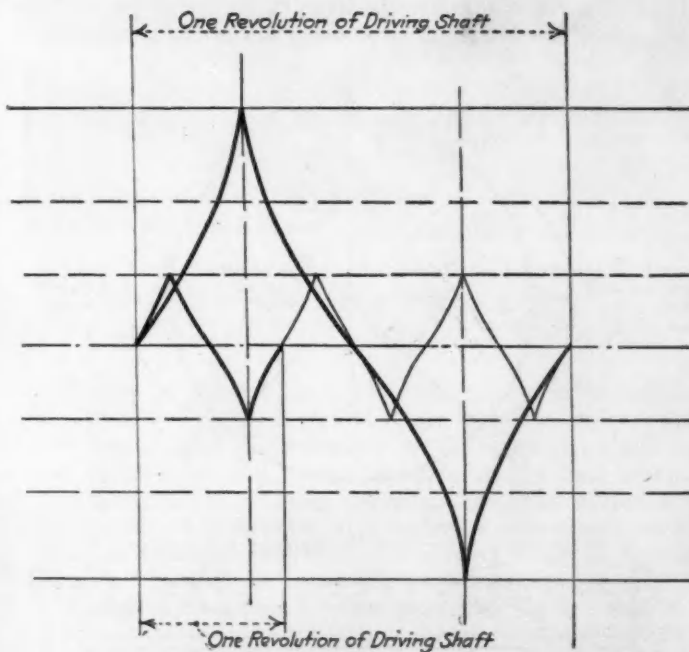


FIG. 3—PATHS OF A MOTOR BEARING DURING A SINGLE REVOLUTION OF THE DRIVING-SHAFT OVER THE SURFACE OF THE SPHERE FOR TWO MOTOR ANGLES

When the Driving-Shaft is Rotated the Combined Action of the Rotary Movement and the Angular Displacement of the Torque Pin, through the Link from the Driving Shaft, Causes the Ball Bearings to Travel at the Angle of Nutation over the Surface of the Sphere and Thus Causes the Motor to Travel about Its Own Axis in the Same Direction of Rotation as That of the Driving-Shaft. The Rotation Increment for Each Nutation Is Dependent Solely upon the Angular Displacement of the Motor as Regulated by the Control Members. When the Motor Is Rocked to a Greater Angle from Its Zero Position, the Motor Bearing and Consequently the Whole Motor Has Moved Farther around Its Own Axis.

the driven part, relatively to the speed of rotation of the driver, is dependent upon the angular displacement of the axis of rotation of the mutator with respect to the axis of nutation, which coincides with the axes of the driving and the driven shafts. When the angular displacement is zero, the speed of the driven shaft is zero, and, as the displacement is increased from zero to the maximum, the speed of rotation of the driven shaft also increases to the maximum. By varying the angular displacement of the nutating body it is possible, therefore, to vary the speed-ratio between the driving and the driven parts from zero to the maximum, the maximum being determined by the maximum angular-displacement that the construction of the transmission will allow.

SINGLE-SPHERE-TYPE HEAVY-DUTY TRANSMISSION

Fig. 1 shows a type that contains all the elements before referred to. The non-nutating body is a stationary sphere, *a*, the inside surface of which is hardened and ground to a true spherical shape. The nutating body *b*, which cooperates with the sphere, is a cup-shaped cage supported within the sphere and adapted to have a movement of nutation as well as a movement of rotation about its own axis. On the outer surface of this mutator at equal intervals are mounted ball bearings *c*, each bearing being mounted in a plane with the mutator axis, and the ball-bearing shafts *d*, lying, therefore, in a plane perpendicular to the mutator axis.

These ball bearings may be ordinary bearings of a standard size, or they may have an extra-heavy outer rim; in either case the face of the outer rim of the bearing is ground to a radius smaller than that of the large sphere. Another method of using the ball bearings is to mount them in steel cages with two bearings mounted on the shaft in one cage. But, irrespective of the mountings of these ball bearings, a point on the outer surface of each of the bearings or cages is always in contact with

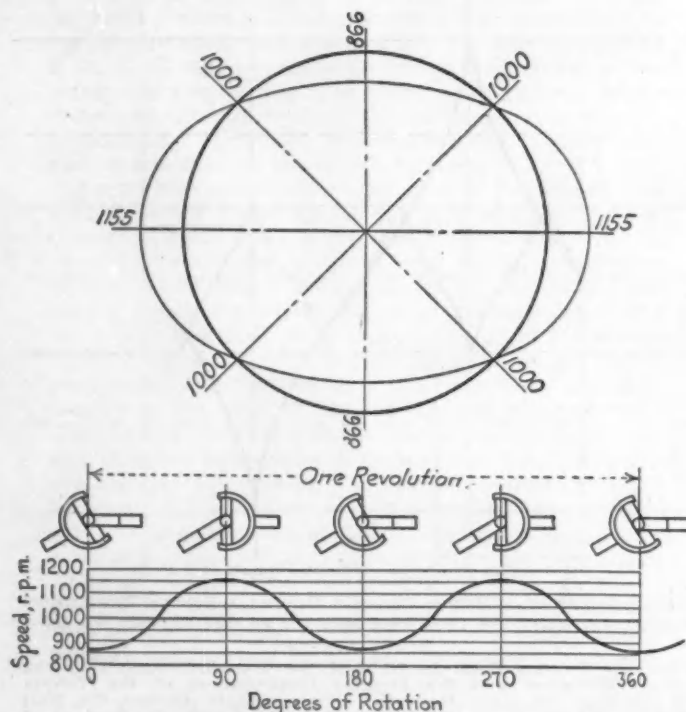


FIG. 4—THE SPEED FLUCTUATION OF THE DRIVEN SHAFT WITH A CONVENTIONAL UNIVERSAL-JOINT FOR A CONSTANT DRIVING-SHAFT SPEED OF 1000 R.P.M. AND A SHAFT INCLINATION OF 30 DEG. Assuming the Normal Angular Velocity of the Driving Shaft To Be Unity, the Minimum Angular Velocity of the Driven Shaft Equals the Cosine of the Shaft Angle and the Maximum Equals the Secant of the Shaft Angle

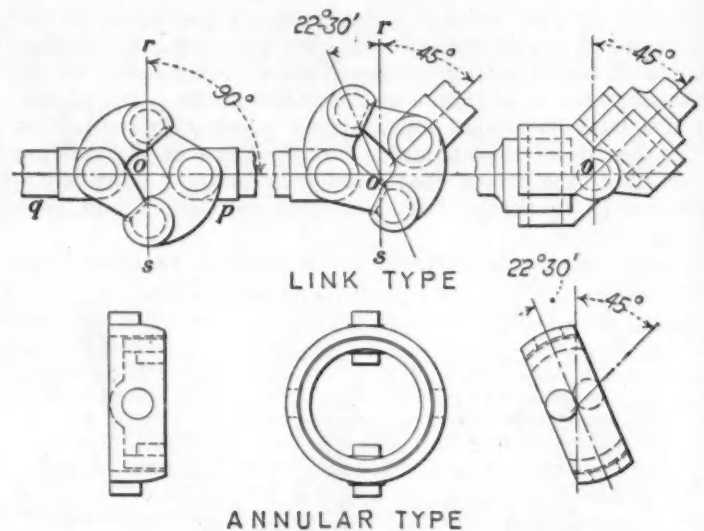


FIG. 5—A DOUBLE UNIVERSAL-JOINT HAVING A CONSTANT ANGULAR VELOCITY

This Joint Consists of Four Links of Equal Length That Move in a Ball-and-Socket Joint at Their Outer Ends and That Are Hinged to Their Shafts at Their Inner Ends. If the Driving and Driven Shafts *p* and *q* Are in Alignment as Shown at the Upper Left Corner, the Mutator Has No Angular Displacement and Is at Rest. If the Mutator Is Displaced at an Angle of 45 Deg. as in the Central and Right Views at the Top, the Ball-and-Socket Joints Move through an Angle of 22½ Deg. because the Radii of the Links Are Equal. Rotation of the Shaft *p* Maintains the Plane in Which the Ball-and-Socket Joint Revolves at an Angle of 22½ Deg. to the Perpendicular —s. The Same Relative Position Obtains at All Angles of Nutation of the Mutator in the Sphere for the Link Type Shown at the Top and the Annular Type Illustrated at the Bottom

some point on the inner surface of the stationary sphere.

The mutator has sections cut out, corresponding to the number of bearings to be mounted in the mutator. The cylindrical ball-bearing shafts *d* are supported at each end by rollers *e* which are curved to receive the ball-bearing shafts, and rest in circumferential grooves provided for them in the mutator.

The driving-shaft *g* runs in bearings and can slide axially in its housing for the purpose of moving the mutator *b* angularly within the sphere *a* and may be moved, whether or not the driving shaft is rotating, by a worm and screw, or in any other manner best suited to the duty to be performed; for example, as shown here in the control *h*. The projecting end of the shaft carries a sliding coupling to engage with the external driving-shaft. To the inner end of the transmission driving-shaft and eccentric with it is attached a forked link, *i*, which runs to and embraces a pin, *j*, lying in the axis of mutator in a sleeve, *k*, Fig. 2, or preferably in ball bearings, and which may be called a torque-pin or mutator-pin. A screw, *l*, is provided to prevent the sleeve *k* or, in commercial forms, the ball-bearing cage, from slipping endwise. Pins *m* connect the sleeve *k* and the forked link *i*. A simple illustration of this construction is presented in the views at the left of Fig. 2.

When the mutator axis coincides with the driving-shaft axis, the torque-pin *j* will also be in axial alignment, and rotation of the driving-shaft will simply revolve the link and sleeve about the torque-pin without causing any movement of the mutator. When the driving-shaft *g* is moved forward from the neutral position by means of the control, the eccentric mounting of the link *i* which runs to the mutator, will cause the mutator to be displaced angularly within the sphere, and the rotation of the driving-shaft will cause the mutator to nutate, the extent of nutation being determined by this angle of displacement.

The driven shaft *n* being connected to the mutator, in a manner to be described later, offers resistance to the movement of the mutator, and this resistance causes the

supporting rollers *e* to roll, or tend to roll, from their middle position in the grooves; this, in turn, increases, or tends to increase, the radial distance of the rollers from the center of the mutor. The view at the right of Fig. 2 illustrates the mounting of a mutor bearing. As the surface of each ball-bearing *c* is in contact with the sphere *a* this shifting of the rollers *e* acting through the ball-bearing shaft *b* creates pressure between the outer surface of the ball bearings and the sphere and, as the load on the driven shaft increases, the pressure between the ball bearings and the sphere will increase proportionately, causing a positive clutch-action for all angular positions of the mutor and for all loads up to the crushing strain. The maximum loads that can be transmitted without crushing are determined by the number of ball

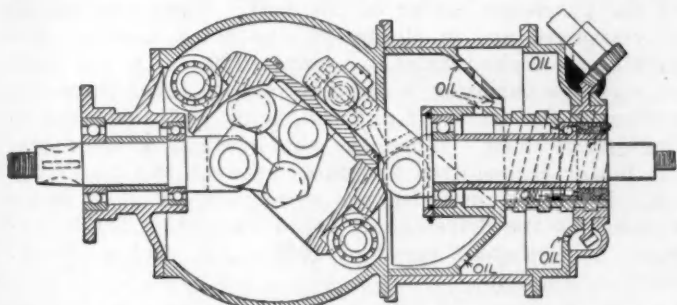


FIG. 6—APPLICATION OF THE LINK TYPE OF UNIVERSAL-JOINT TO A TRANSMISSION
This Transmission Is a 12-In. Single-Sphere Heavy-Duty Unit

bearings on the mutor, the load-capacity per bearing, the radius at which the bearings are mounted, and the like.

POSITIVE COOPERATIVE REACTION

The pressure caused by the movement of the rollers to one side or the other of the grooves ensures positive cooperative reaction between the mutor and the sphere. When the driving-shaft is rotated, the combined action of the rotary movement and the angular displacement of the torque-pin through the link from the driving-shaft, causes the ball bearings to travel at the angle of nutation over the surface of the sphere, and thus causes the mutor to travel about its own axis in the same direction of rotation as that of the driving-shaft. The rotation increment for each nutation is dependent solely upon the angular displacement of the mutor as regulated by

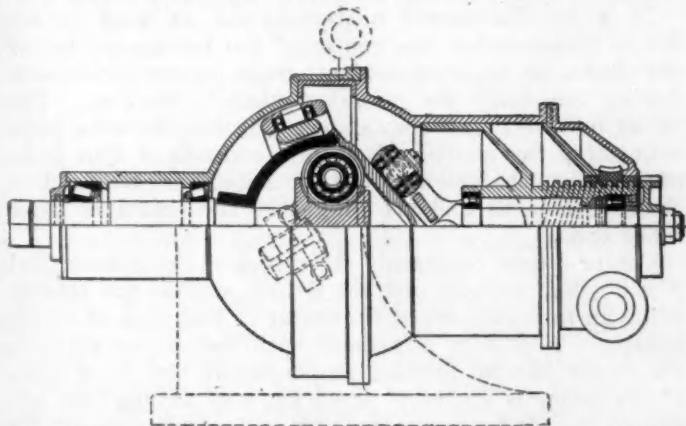


FIG. 7—THE ANNULAR TYPE OF UNIVERSAL-JOINT AS INCORPORATED IN A TRANSMISSION

In the Annular Type the Four Links and the Ball-and-Socket Joints of the Link Type Are Replaced by Two Annular Members. This Form of Universal-Joint Is Required where the Joint Is Used Exterior to the Mutor in a Single-Sphere Transmission. It also Lends Itself Better to the Application of Ball Bearings To Eliminate Friction Losses

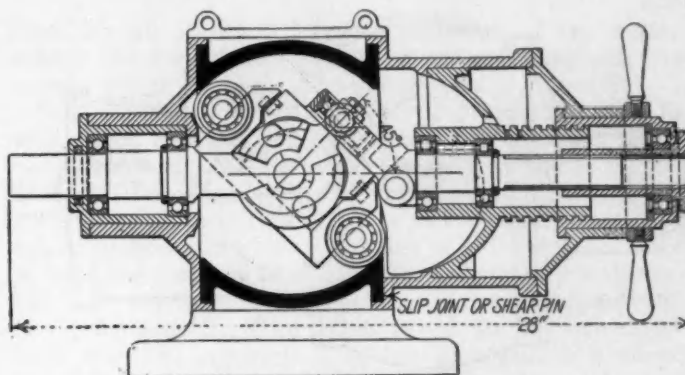


FIG. 8—LONGITUDINAL SECTION OF A TRANSMISSION EQUIPPED WITH A STEEL-BALL-TYPE UNIVERSAL-JOINT
This Transmission Has a Greater Capacity on Account of the More Powerful Form of Universal-Joint

the control members. Fig. 3 shows, for a single revolution of the driving-shaft, the paths of a mutor bearing over the surface of the sphere for two mutor angles. It will be seen that the mutor bearing, and, consequently, the whole mutor, has moved farther around its own axis, that is, the mutor axis, when the mutor has been rocked to the greater angle from its zero position. It is then easy to see why the speed of the mutor, for a constant driving-shaft speed, depends simply upon its angle of displacement.

At the zero position, or at any angle of inclination, it

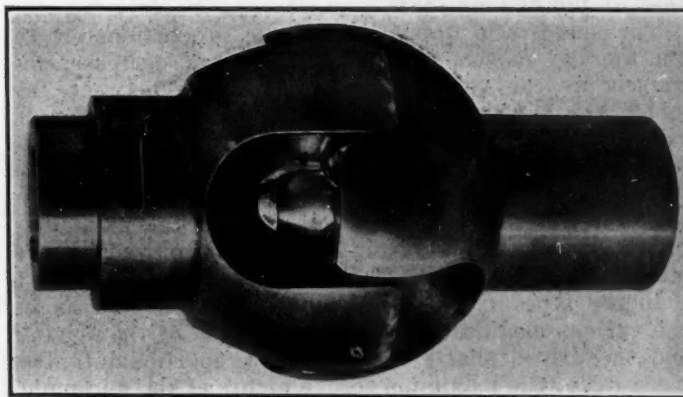


FIG. 9—EXTERIOR VIEW OF A STEEL-BALL UNIVERSAL-JOINT
This Joint besides Having Constant Angular Velocity and Very High Efficiency Is Said To Have a Greater Torque Capacity for a Given Diameter than the Conventional Type of Joint and To Require Less Attention and Lubrication as the Movement Is Rolling Only

will now be evident that, while the mutor gives rotation to the driven shaft, it cannot itself rotate on its own axis, for the resistance, or torque, from the driven shaft will set up proportional radial pressure on the ball bearings and prevent any rotation of the mutor. The mutor, however, can be displaced angularly by movement of the control members, whether the driving-shaft is rotating or not. The torque being transmitted does not react on the control members, but the frictional force required to displace the mutor angularly, by movement axially of the driving-shaft in the housing, naturally increases somewhat as the torque increases.

If the mutor could be tilted angularly to 90 deg. from the driving-shaft angle, the speed of the driven shaft would be the same as that of the driving-shaft. In this position the mutor would have no nutating movement and would not rotate on its own axis but would revolve bodily in the sphere. Shifting the mutor angularly from the 90-deg. position would thus decrease the speed-ratio from 1 to 1 down to a zero speed of the driven shaft,

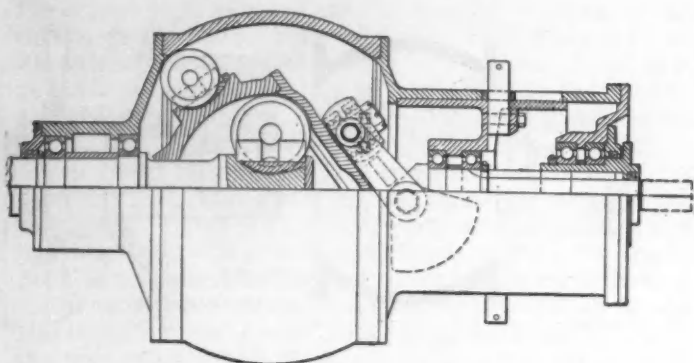


FIG. 10—A HEAVY-DUTY FORM OF TRANSMISSION IN WHICH THE UNIVERSAL-JOINT IS NOT USED AS THE CONNECTING MEMBER BETWEEN THE MOTOR AND THE DRIVEN SHAFT

In This Arrangement the Motor Shaft Extends into the Spherical Hollow of the Motor and Carries a Series of Ball Bearings Mounted on Shafts and Rollers That Are Identical with the Motor Bearings Previously Described and the Action of the Motor Sphere and the Ball Bearings Caused by the Driven Shaft Is Identical with That of the Outer Stationary Sphere and the Motor Ball Bearings. The Nutating Movement of This Form of Motor Causes Twice as Great an Advance of the Driven Shaft in Relation to the Driving One and for All Identical Angular Positions of the Motor Sphere and for the Same Driving-Shaft Speed, the Horsepower Is Doubled

when the torque-pin reached the driving-shaft axis. With the construction as described, it is not actually possible to tilt the motor to the 90-deg. position, the maximum angle to which the construction will allow the motor to be displaced being approximately 48 deg., giving a maximum driven-shaft speed of about one-third that of the driving-shaft.

The speed-ratio does not decrease proportionately to the angular movement of the motor, but decreases inversely as the versed sine of the angle between the motor axis and the axis of the driving-shaft. The speed-ratio formula for this single-sphere type of transmission then is $1/(1 - \cos \alpha)$, α being the angle between the motor axis and the driving-shaft axis. It will also be seen that the driven-shaft speed varies with the axial displacement of the motor-pin from its zero position, as measured on the driving-shaft axis.

In the type of transmission described, as well as in the various modifications, the torque-ratio of the driving and the driven shafts is inversely proportional to the speed-ratio; the maximum torque occurs at the minimum speed. As the nutation angle approaches zero, the torque-factor becomes the minimum for the driving-shaft and the maximum for the driven shaft; it approaches infinity in both directions. This characteristic conforms to the requirements of power transmission

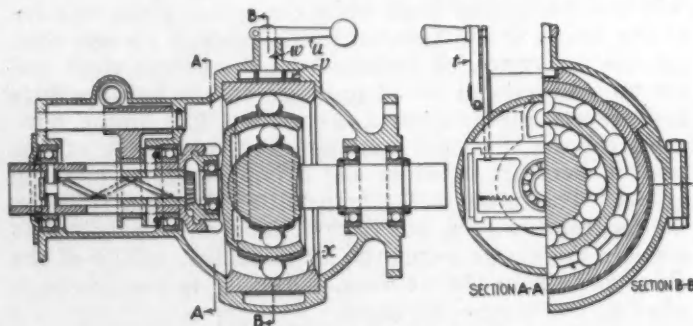


FIG. 11—A TWO-SPHERE TYPE OF TRANSMISSION IN WHICH STEEL BALLS INSTEAD OF BALL BEARINGS ARE USED

The Driven Shaft Is Positively Locked against Rotation in Either Direction when the Motor Is in Its Zero Position. In Lathes or Other Machine Tools Ability to Move the Driven Shaft Independently of the Driving Shaft Is Desirable. This Is Accomplished in This Transmission by Releasing the Friction Clutch Band w by Moving the Eccentric e of the Lever Handle u , Thus Permitting the Clutch Member x To Rotate Freely in Its Bearings in the Housing and Allowing the Operator To Stop or Start the Driven Shaft Quickly without Shifting the Speed Controller

from engines of low starting-torque, such as the internal-combustion engine or the alternating-current electric motor.

A FORM OF UNIVERSAL-JOINT

In the single-sphere type of transmission under consideration, the connection between the motor and the driven shaft may be called a double universal-joint and is designed to give a constant angular-velocity of the driven shaft, as contrasted with the fluctuating speeds that would result from the use of the ordinary universal-joint.

A number of well-known forms of universal-joint transmit motion between two shafts rotating at an angle to each other. Two identical fork-members are generally joined together by a third so that their axes intersect in the geometric center of the unit. When two shafts so connected are in alignment, the third member connecting the forks rotates in a plane at 90 deg. to the shaft axis and no variation in angular velocity takes place, the motion of the driver, if uniform, being so transmitted to the driven shaft. When the shafts stand at an angle, the power transmitted fluctuates between the maximum and the minimum twice per revolution. Fig. 4 shows graphically the driven-shaft speed fluctuation for a constant driving-shaft speed of 1000 r.p.m. and a 30-deg. shaft-inclination.

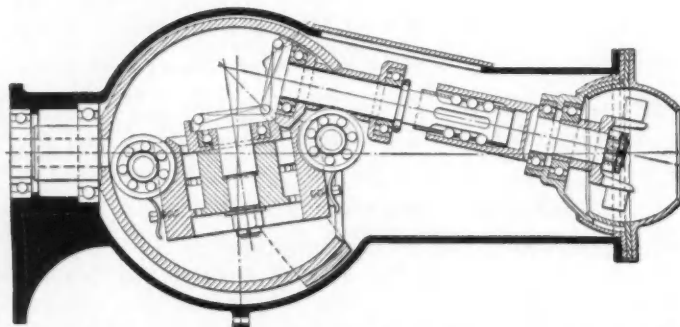


FIG. 12—AN APPLICATION OF THE TRANSMISSION TO A MOTOR CAR. This Transmission Has Been in Service for the Last 3 Years. The Driving End Is Supported by Ball Bearings in the Oil-Tight Housing and the Motor Bearing Is Located in a Frame Whose Trunnions Are Supported in the Housing and Which Projects Sufficiently To Attach the Speed Control That Operates To Change the Angular Displacement of the Motor While the Sphere Is Rotating or at Rest. The Connecting Member between the Motor and the Driven Shaft Is Designed To Deliver a Uniform Angular Movement for All Motor Angles. This Joint Consists Essentially of a Pair of Gears and Is Shown 8 Deg. beyond the Center Line of the Neutral Position for Reversing

In a non-fluctuating universal-joint as used in the Weiss transmission, the center of the ball-and-socket of the links, or their equivalent, must rotate in a plane having one-half the angular shaft-inclination. The upper half of Fig. 5 shows such a double universal-joint connecting two shafts. This joint consists of four links of equal length, which move in a ball-and-socket joint at their outer ends and are hinged to the shafts at their inner ends.

Center o here represents the center of the sphere, and p and q the driving and the driven shafts, the former being an integral part of the motor in this type of transmission. If p is in alignment with the driven shaft q , the motor has no angular displacement and is at rest. If the motor is displaced at an angle of 45 deg., for example, the ball-and-socket joint will move through 22 deg. 30 min. because the radii of the links are equal. Rotation of the shaft p on its own axis in this position maintains the plane in which the ball-and-socket joint revolves at 22 deg. 30 min. to the perpendicular $r-s$. The same relative position obtains at all angles of nutation

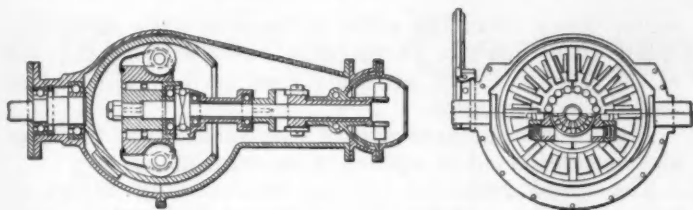


FIG. 13—A SIMILAR TYPE OF TRANSMISSION TO THAT ILLUSTRATED IN FIG. 12 IN THE DIRECT DRIVE POSITION

When the Mutor Is in a Vertical Position at 90 Deg. to the Sphere-Shaft Axis, Both Shafts Are in Alignment and All the Teeth of the Gear Joint Are in Mesh as in a Jaw Clutch. In This Direct Drive Position the Mutor and the Sphere then Revolve Together at Equal Speeds and the Mutor Ball Bearings Do Not Rotate on Their Own Axes Because Each Ball Bearing Is at 90 Deg. to the Axis of Rotation of the Sphere

of the mutor in the sphere. Fig. 6 shows such a joint in the transmission.

In the annular type of this universal-joint, the four links are represented by two annular members in place of the links and ball-and-socket joints. The annular form is necessary where the joint is used exteriorly to the mutor in the single-sphere transmission as shown in the lower part of Fig. 5 and in Fig. 7. It also lends itself better to the application of ball bearings to eliminate friction losses.

Fig. 8 shows a transmission equipped with a steel-ball type of universal-joint. This joint is shown more clearly in Fig. 9. This makes a durable and highly efficient joint that has a greater torque-capacity for a given diameter than the conventional type of joint and requires less attention and lubrication, as the movement is rolling only. This joint is also applicable to any type of automotive vehicle, irrespective of the type of transmis-

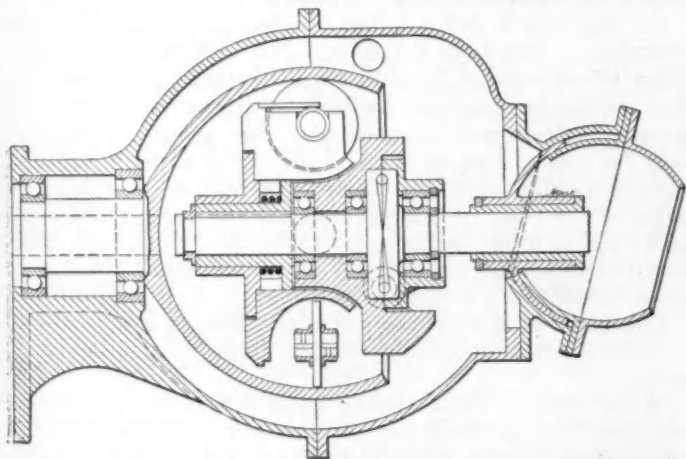


FIG. 14—ANOTHER TYPE OF MEDIUM-DUTY TRANSMISSION THAT HAS BEEN TESTED IN MOTOR CARS

This Type Uses Metal Discs Supported in Ball Bearings To Co-operate with the Sphere

sion used, and offers the very desirable feature of giving uniform propeller-shaft speed.

HEAVY-DUTY FORM WITHOUT UNIVERSAL-JOINT

The heavy-duty form of transmission shown in Fig. 10 does not use the universal-joint as the connecting member between the mutor and the driven shaft. The driven shaft extends into the spherical hollow of the mutor and carries a series of ball bearings mounted on shafts and rollers identical with the mutor bearings already described, and the action of the mutor sphere and the ball bearings carried by the driven shaft is identical with that of the outer stationary sphere and mutor ball-bearings. The nutating movement of the mutor in this form causes twice as great an advance of the driven shaft as in the single-sphere types and, there-

fore, for all identical angular positions of the mutor sphere and for the same speed of the driving-shaft, the horsepower is doubled. The speed-ratio is $(1/\sin \alpha)^2$.

Fig. 11 shows a two-sphere type of transmission in which steel balls instead of ball bearings are used in co-operation with the spheres. Besides a speed-control lever, t , a lever handle, u , and friction-clutch band, v , are also shown. The driven shaft is locked against rotation in either direction while the mutor is in its zero position. In machine tools, as in a lathe, for example, it is desirable to be able to move the driven shaft independently of the driving-shaft. The releasing of the friction-clutch band v by the eccentric w of the lever handle u allows the clutch member x to rotate freely in its bearings in the housing, so that the operator may at any time quickly

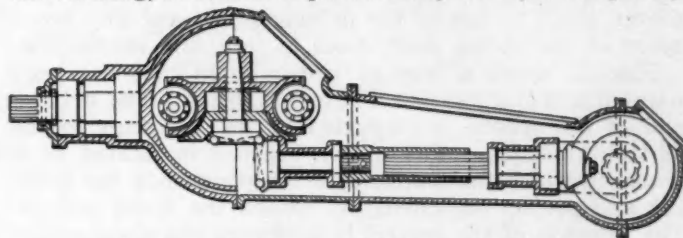


FIG. 15—ANOTHER MEDIUM-DUTY FORM

In This Construction a Semi-Sphere Is the Driver and the Mutor Can Be Disengaged from the Sphere. A Movement of the Sphere or the Mutor Away from the Other Suffices To Allow Either To Rotate Independently of the Other and without the Use of the Friction Clutch Generally Provided between the Engine and the Transmission

stop or start the driven shaft without shifting the speed-controller. Inasmuch as a power-transmission device of this type produces infinite leverage, the friction band also acts as a safety device that yields to the maximum allowable torque. Practically any number of cutting-speeds desired can be marked on the control dial, and then any speed can be immediately obtained by placing the controller at the proper position as indicated on the dial.

In the transmissions so far described the outer sphere is held stationary against torque reaction and the shaft is rotated. If this condition is reversed, and the shaft is held stationary, the sphere rotates, obviously in the opposite direction, but the speed-ratios are not the same as before. In the single and two-sphere forms the maximum mutor-angular-displacement gave 1 to 1, in the imaginary position of a 90-deg. mutor angle. In this position, with the shaft held stationary, the speed of the sphere in the opposite direction is infinite. The practical maximum mutor-angle is approximately 48 deg., as in the type previously described. The speed-ratios are: for the single-sphere form, $\cos \alpha / (1 - \cos \alpha)$, and for the two-sphere form $(\cos \alpha / \sin \alpha)^2$.

Many other modifications of heavy-duty types of Weiss transmission have been designed for various uses, including types giving what we may call an over-speed,

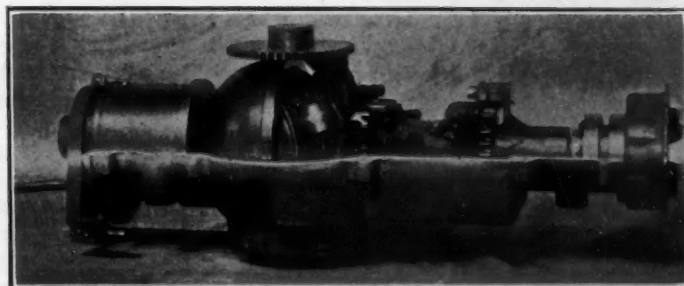


FIG. 16—EXTERIOR VIEW OF A SEMI-SPHERE TYPE
This Type Has Also Been Tried Out in Service on an Automobile

and types that are reversible without the use of gears and in which the speed runs up to the maximum in both directions, thus meeting the requirements for uses such as those of locomotives and motor rail-cars. However, the types so far described illustrate a few representative designs of heavy-duty transmission.

THE MEDIUM-DUTY TYPE OF TRANSMISSION

The designation of medium duty has been chosen for the form in which the sphere is the driver and rotates in fixed bearings. The mutator also rotates, but neither the sphere nor the mutator have nutating movements of their own. Nevertheless nutation kinematically occurs as a result of the relative angular divergence. In this form direct drive is obtained, that is, one revolution of the driven shaft to one of the driving-shaft, and any lower speed of the driven shaft down to zero, and the reverse.

Fig. 12 shows a type of transmission that has been used in a motor car for the last 3 years. The driving end of the sphere is supported by ball bearings in the oil-tight housing. The mutator bearing is located in a frame in which the trunnions are supported in the housing and project sufficiently to attach the speed control. The function of the control is to change the angular displacement of the mutator, while the sphere is rotating or at rest. The connecting member between the mutator shaft and the driven shaft is designed to deliver uniform angular movement for all mutator-angles. This joint, as shown, consists substantially of a pair of gears. The bearing supporting the driven-gear shaft is hinged to the mutator frame at a point tangential to the pitch-line of the gear-joint. As the teeth are cut in a circular shape, a rolling-line contact on the pitch-line is secured at all angular positions to which the gear-joint may be swung. When the mutator is in a vertical position, 90 deg. to the sphere shaft axis, both shafts are in alignment and all the teeth of the gear-joint are in mesh, as in a jaw-clutch. This is the direct-drive position, or the 1 to 1 speed-ratio. The mutator and the sphere then revolve together at equal speeds, and the mutator ball-bearings do not rotate on their own axes because the point of ball-bearing contact in the sphere and the mutator lie in the same plane of rotation. Fig. 13 shows a similar type of transmission in this direct-drive position.

Displacing the mutator angularly toward the horizontal decreases the speed of the driven shaft which becomes zero when the mutator plane and the sphere-shaft axis coincide. A further displacement of the mutator in the same direction results in reversing the direction of rotation. The reverse speed of rotation is limited, in the transmission shown, to approximately 8 deg. of the mutator angle beyond the zero position, which corresponds to a speed-ratio of seven revolutions of the sphere to one of the driven shaft. The driven shaft following the mutator angular-displacement requires a universal-joint and a slip-joint of some suitable form, such as that shown. It will be noted that in this form of transmission the whole mutator, which is split, is made to expand under torque by a set of rollers tending to roll up on their supporting grooves, so that the pressure of the ball bearings against the sphere is always in direct proportion to the torque.

Fig. 14 shows another medium-duty type of transmission, which has been tested in an automobile. This type employs metal discs supported in ball bearings to cooperate with the sphere.

Fig. 15 illustrates a medium-duty form in which a semi-sphere is the driver and the mutator can be disengaged from the sphere. A movement of the sphere or the

mutator away from the other suffices to allow either to rotate independently of the other, and without the use of the friction clutch generally used between the engine and the transmission.

Fig. 16 is a photograph of a semi-sphere type that has also been tried out in service in an automobile.

The speed ratio for all the medium-duty forms is $1/\sin \alpha$, where α is the angle between the mutator plane and sphere axis.

ADVANTAGES FOR AUTOMOTIVE VEHICLES

The simplicity of control with a Weiss transmission will be readily apparent. Any speed-ratio from the maximum to zero, and reverse, can be obtained by moving a control-lever without recourse to a clutch, as is necessary during the conventional gear-shifting. This ease of control has been demonstrated in a motor car in the traffic of the largest cities. The change in speed-ratio, starting, stopping and reversing are all readily accomplished by simply moving the control-lever.

The feature of greater safety is also present because of this ability to obtain almost instantly any desired higher or lower speed-ratio and, if it is necessary to stop the car suddenly, the control-lever can be quickly brought to the zero position and the rear wheels actually locked against rotation by the transmission. This characteristic is also important on hills, for the reason that if the car must be stopped, shifting the control-lever to zero not only stops the car, but locks it against backing, without the use of brakes. The same feature holds good going down-hill, for when the transmission ratio is lowered, the speed of the car is checked and, when put on the zero position, the car is locked.

It will also be evident that the flexibility with a transmission of this type surpasses that attainable with any type of step-speed transmission. In starting a vehicle the engine is never for an instant disengaged from the propeller-shaft and, consequently, the speed of the car can be accelerated on a level or on hills more rapidly than with any step-speed drive. A still greater advantage of the constant engagement of the engine is found in climbing hills, as the speed-ratio can be dropped back to the exact ratio needed. With a step-speed transmission, besides the danger of disengaging the engine on a hill, some of the car momentum is always lost, so that it often proves necessary to drop back to a still lower speed.

A car with a Weiss transmission was recently driven over the Lincoln Highway to Michigan. On the notorious grades of the Alleghany Mountains, it was found that the car, although an old one, possessed remarkable hill-climbing ability. The reason, of course, was the fact that the speed-ratio could be regulated accurately for any grade, to allow the engine to run constantly at the speed at which its maximum horsepower is developed.

The ease of changing speed-ratios also opens the way to the use of a higher gear-ratio in the rear axle, giving fast car-speeds without causing the engine to race and, incidentally, adding to the comfort of the passengers as well as increasing the life of the engine and of the car in general. The transmission may then be used to adapt the load of the car to allow the engine to run constantly at a more efficient speed and, therefore, under the most favorable conditions with respect to fuel economy. The fuel saving thus made possible is very considerable and it is thoroughly practicable to use a rear-axle ratio of 2.5 to 1 instead of 4 to 1 for instance, for the reason

(Concluded on p. 104)

Engine-Oil Consumption and Dilution

By NEIL MACCOULL¹

SEMI-ANNUAL MEETING PAPER

Illustrated with CHARTS AND PHOTOGRAPHS

AN independent study of a similar nature to that made by the Bureau of Standards on fuels in 1923 was conducted by the company the author represents, and the paper presents first the results of the tests made on five 7½-ton trucks during the regular course of business deliveries. Curves plotted from the data thus obtained are presented and analyzed in considerable detail.

These data were then utilized as a basis for a series of dynamometer experiments in an attempt to explain further the effects of the many temperature and mechanical variables on the rate of oil consumption and oil dilution when only one factor was allowed to vary at a time.

The dynamometer apparatus and the engine used are described, together with the test routine, and an analysis is made of the result of wear of the test engine. The "standard" conditions under which the test runs were made are stated. Each series of runs was made by varying only one of these standard variables at a time; all others were held constant. The runs of Series A relate to carburetor setting, and those for the subsequent series have to do with load, oil volume, crankcase temperatures, carburetor air-temperature, cylinder-jacket temperature and engine speed. Curves plotted from data obtained in each series of tests are presented and analyzed, and, as an indication of the general trend of the results that may help to solve some of the perplexing lubrication problems now current, five tentative conclusions are specified.

CONTEMPORANEOUSLY with the road-tests made by the Bureau of Standards on fuels in 1923, the company with which I am associated made an independent study of a similar nature. The work was done on five Mack 7½-ton trucks during the regular course of business deliveries. We took precautions to have all these trucks in as nearly identical mechanical condition as possible, yet they showed so great a difference in oil performance as to cause some surprise. For instance, there was a great difference in dilution, as shown by Fig. 1, which is typical of the results of daily tests of the viscosity of the oil in the crankcase of each truck. The fuel and lubricating oil were the same in each instance. The gasoline consumption varied from 2.2 to 3.0 miles per gal., but in no consistent way to suggest that it might have been a cause for the different dilutions. The only other evidence we could find of difference in the behavior of these trucks was in their rate of lubricating-oil consumption, which varied from 79 to 450 miles per gal., a variation of 500 per cent. In Fig. 2 the oil viscosity at the end of 300 miles is plotted against the rate of oil consumption, as well as the temperatures recorded for the first 2 days of each run, and the gasoline consumption. This figure shows why we dropped all the known variables except the rate of oil consumption, at first, in our search for the possible causes of the great variation of dilution.

Before leaving the data from these road-tests, attention should be called to the shape of the curves in Fig. 1,

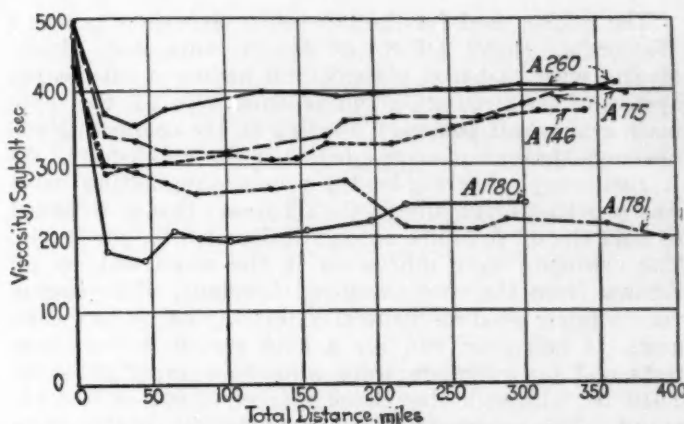


FIG. 1—CHART SHOWING THE VARIATION IN THE DILUTION OF THE CRANKCASE OIL FOR FIVE 7½-TON TRUCKS

These Curves Are Plotted from the Results of Daily Tests of the Viscosity of the Oil in the Crankcase of Each Truck and Show Typical Results. The Vehicles Were Used in Making Regular Deliveries and Care Was Taken To Have the Trucks in as Nearly Identical Mechanical Condition as Possible. The Fuel and the Lubricating Oil Were the Same in Each Instance

which are typical. They show that an unlimited progressive loss of viscosity does not occur but that a condition of equilibrium is reached after a moderate length of time, after which no further dilution will take place. Several instances are shown where the elements that control this point of equilibrium have apparently changed during the test and the oil viscosity has actually risen. With such curves before one, it is indeed difficult to tell an automobilist how many miles he can drive his car before he must change his oil, if dilution is assigned as the sole reason for the change.

We use viscosity as a measure of dilution in all our present work, since it is more practicable to do this than to determine the actual percentage of dilution by distilling each sample. To convert viscosity readings to their equivalent percentage of dilution, we use a curve that was determined by distillations of oil samples taken at the end of each of our truck tests. We distill at an absolute pressure of 235 mm. of mercury, until the temperature of the liquid rises to 675 deg. Fahr. For the particular oil used in our road-tests, this leaves the oil with practically the same viscosity and flash-point as those of the unused oil. In Fig. 3 are shown the results from 22 such distillations, where the percentage found by distillation has been plotted against the viscosity before distillation. This is the curve we have used in all subsequent work to determine the percentage of dilution directly from the viscosity and without distillation.

We found that the diluent separated from all our samples of used oil was approximately uniform in consistency. Individual trucks, even with widely different fuels, made but little difference. An average distillation curve of the diluent separated is given in Fig. 4 as a matter of interest.

All these road data have been suggestive and were thought to constitute good groundwork on which to carry on an accurate series of dynamometer experiments to see

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if we could explain further the effects of the many temperature and mechanical variables on the rate of oil consumption and oil dilution when only one factor is allowed to vary at a time. Furthermore, it seemed that if we could find out why truck No. 1781 gave much better oil-performance than the other trucks, we might be able to get the other trucks into this same condition or even into a better condition.

DYNAMOMETER APPARATUS

The engine used for the laboratory experiments was a Waukesha, Model DU-8, of 4½-in. bore and 6¼-in. stroke, with cast-iron pistons, and having a lubrication system of the circulating full pressure type for the three main crankshaft bearings, feeding to the connecting-rod bearings through passages drilled in the crankshaft. As is customary, a spring-loaded pressure-regulating valve was provided originally in the oil lines; this is intended to hold the oil pressure automatically at 8 lb. per sq. in. The cylinders were lubricated in the usual way by oil thrown from the connecting-rod bearings. The engine was in fairly good mechanical condition, but by no means new. It had been run for a long period before these tests and the cylinders were worn to a taper of about 0.010 in., although they were scarcely 0.002 in. out-of-round. The engine thus represented more nearly than would an engine just out of the factory, an average engine such as is found in service.

The engine was coupled to a conventional Sprague

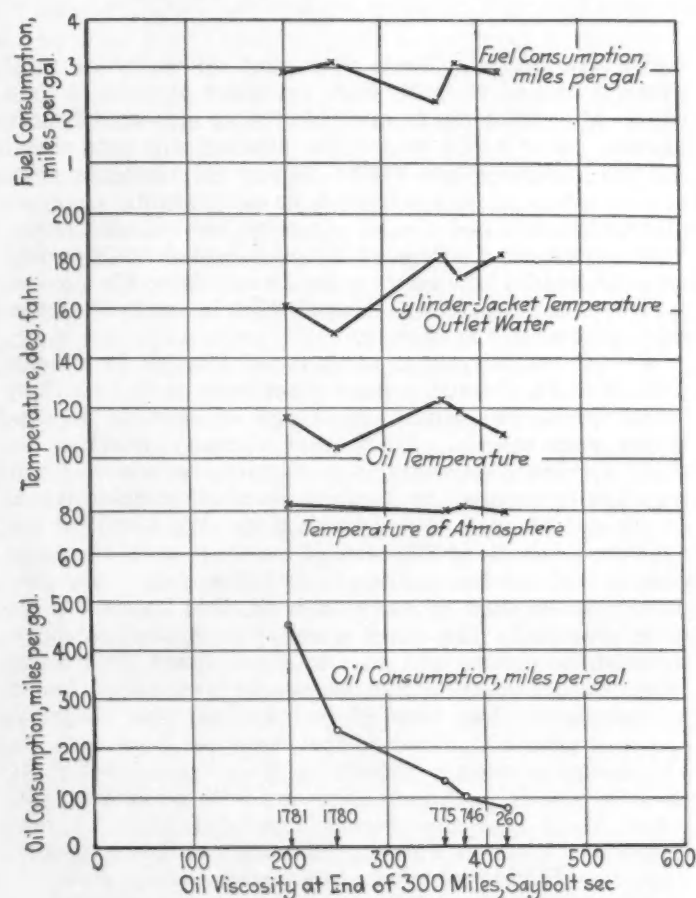


FIG. 2—SOME OF THE DATA OBTAINED AS A RESULT OF THE TESTS. These Curves Show the Rate of Oil Consumption Plotted Against the Viscosity of the Oil at the End of 300 Miles of Running; the Atmospheric, Oil and Outlet-Water Temperatures for the First 2 Days of Each Run and the Fuel Consumption for the Same Period. These Curves Show Why All the Known Variables, Except the Rate of Oil Consumption, Were Dropped at First in the Search for the Possible Causes of the Wide Variation in the Dilution

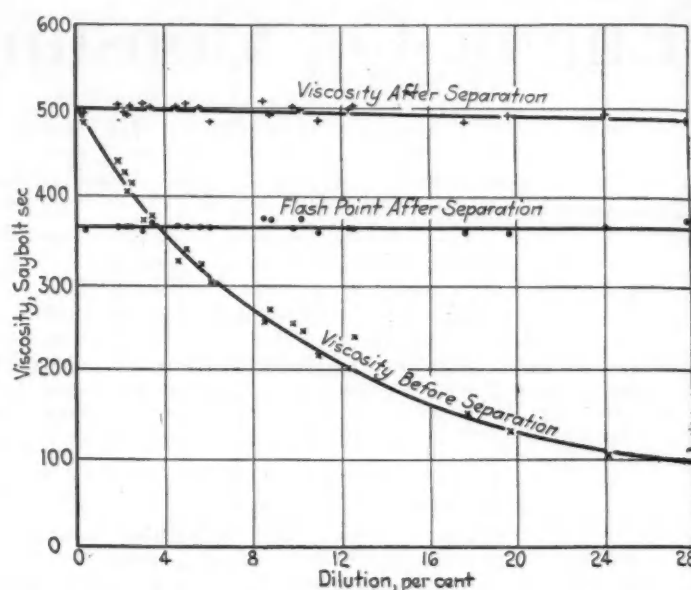


FIG. 3—RESULTS OF DISTILLATION TESTS MADE TO DETERMINE IF THE VISCOSITY CAN BE USED TO MEASURE THE DILUTION

Using the Viscosity as a Measure of Dilution Was Found To Be More Practicable than To Determine the Actual Percentage of Dilution by Distilling Each Sample. The Distillation Was Run at an Absolute Pressure of 235 Mm. of Mercury until the Temperature of the Liquid Rose to 675 Deg. Fahr. For the Particular Oil Used the Viscosity and the Flash Point Were Practically the Same as the Unused Oil. The Curve of the Percentage of Distillation Plotted Against the Viscosity before Distillation Was the Curve Used in Subsequent Work To Determine the Percentage of Dilution Directly from the Viscosity

electric dynamometer. Fig. 5 shows the set-up. A Toledo scale is used for reading the torque, and a chronometric tachometer for reading the speed. The fuel is measured volumetrically by suitable glass pipettes, and hot-air stoves are arranged for the control of the carburetor air-temperature, there being no hot-spot effect on the intake-manifold. The throttle is set to maintain the desired manifold-vacuum below atmospheric pressure, as read by a mercury manometer. A special spark-gap is arranged to make visible the exact spark-timing. The water-pump was remounted so as to run at twice its normal speed and, in consequence, the water circulation is rapid enough to hold the difference

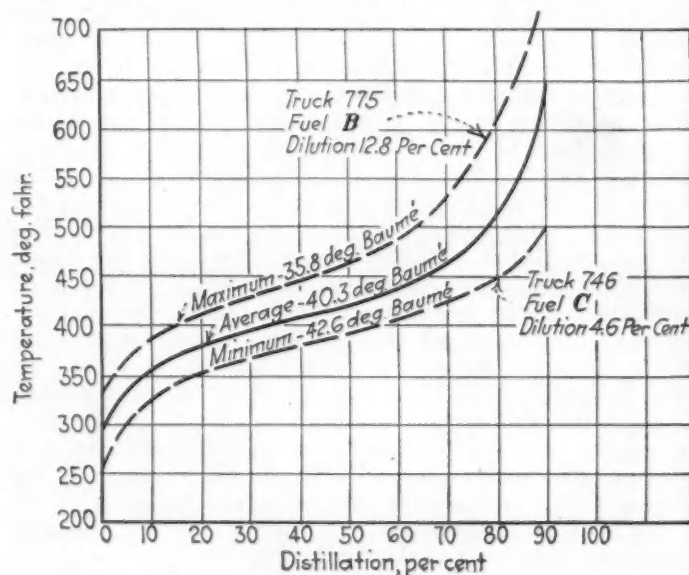


FIG. 4—DISTILLATION CURVES OF THE DILUENT SEPARATED FROM TWO TRUCKS AND THE AVERAGE DISTILLATION FOR ALL FIVE TRUCKS. The Diluent Separated from All Samples of Used Oil Was Approximately Uniform in Consistency and Individual Trucks, Even with Widely Different Fuels, Made but Little Difference

in temperature between the outlet and the inlet jacket-water as it passes through the engine to about 12 deg. fahr. under "standard" full-load conditions. Mercury thermometers, suitably placed, are used for reading temperatures. The crankcase temperature is read from a thermometer projecting a few inches through the rear hand-hole cover in the crankcase.

All the foregoing features are customary, but special attention is called to the details of the lubricating system, some of which are unusual. In the first place, it was considered desirable to know the volume of oil passing through the crankshaft bearings, which of course controls the volume of oil reaching the cylinder-walls. This was accomplished by blocking the oil pressure-regulating bypass valve, so that no oil could pass through it. The oil-pump itself then became a meter of the oil volume passing through the bearings. The oil pressure thus adjusts itself to whatever value is necessary to force the required volume of oil through the bearings. This alteration, though simple in itself, is really far-reaching in effect because, by such an arrangement, a uniform volume of oil is thrown onto the cylinder-walls at each revolution of the engine, regardless of bearing clearance, engine speed and oil temperature or viscosity. The column of oil flowing through the bearings was brought under control by mounting the oil-pump outside the crankcase at the front of the engine where it was driven by change gears.

The second important change consisted in the use of the so-called "dry-sump" system, all the oil being drained

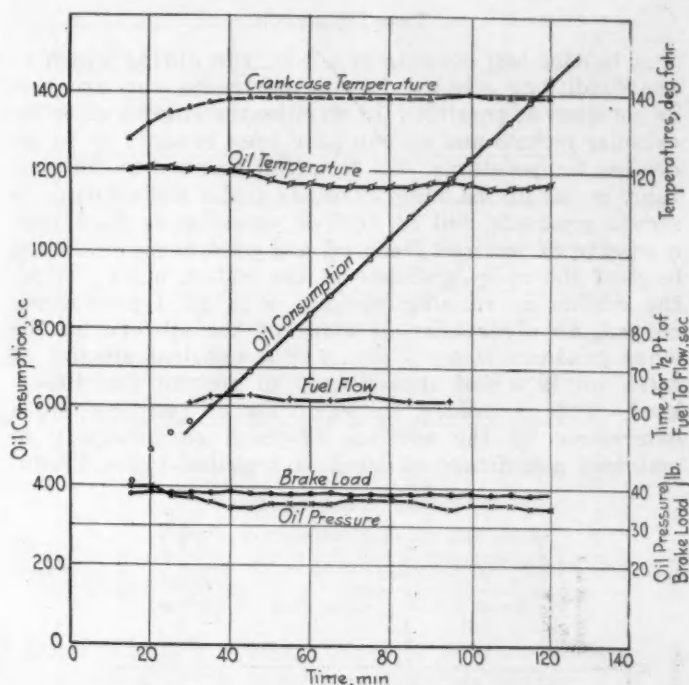


FIG. 6—TYPICAL CURVE OF TEST RESULTS
Readings Were Taken Every 5 Min. of the Oil Drawn from the Reservoir To Maintain a Constant Level in the Glass "Sump" Graduate, the Oil Pressure and Temperature, the Crankcase Temperature, the Fuel Flow and the Engine Torque. The Regularity of the Oil-Consumption Readings Should Be Noticed

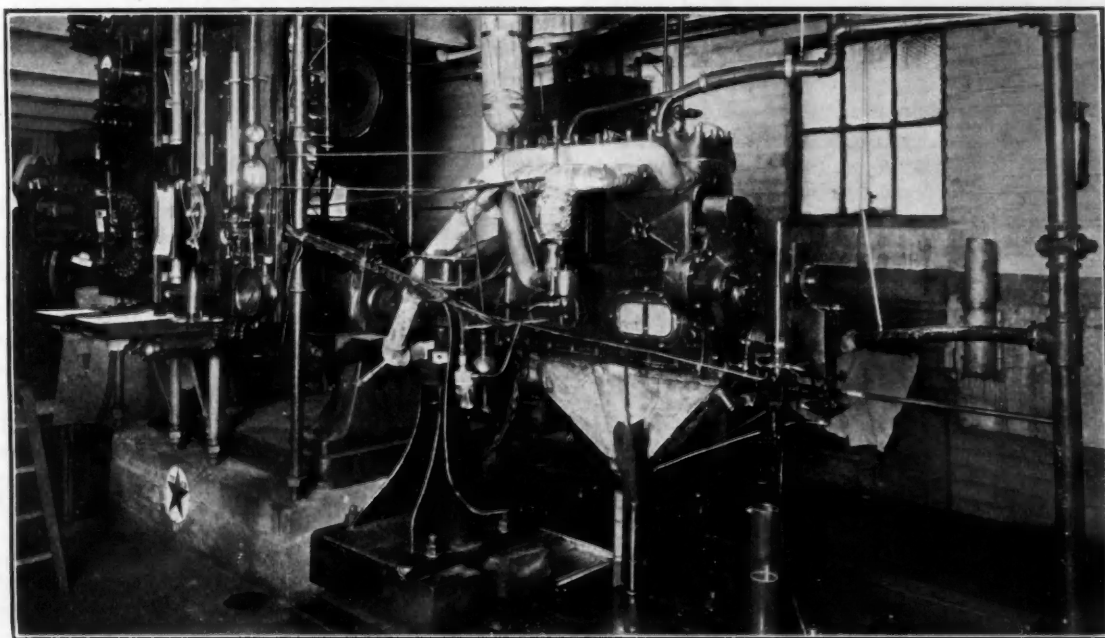


FIG. 5—ARRANGEMENT OF APPARATUS USED FOR MAKING THE DYNAMOMETER TESTS IN THE LABORATORY

The Engine, Which Had a Bore of $4\frac{1}{4}$ In. and a Stroke of $6\frac{1}{4}$ In., Was Coupled to a Conventional Electric Dynamometer. The Lubrication System Was of the Circulating Full-Pressure Type for the Three Main Crankshaft Bearings and then to the Connecting-Rod Bearings by Passages Drilled in the Crankshaft. To Determine the Volume of Oil Passing through the Crankshaft Bearings, Which Determines the Quantity Reaching the Cylinder Walls, the Oil Pressure-Regulating Bypass Valve Was Blocked, Thus Making the Oil-Pump a Meter of the Volume of Oil Passing through the Bearings. A So-Called "Dry" Sump System Was Used. All of the Oil Being Drained from the Oil-Pan into a Glass "Sump" Graduate from Which the Oil-Pump Suction Was Run. The Crankcase Was Water-Jacketed To Control the Temperature of the Oil

from the oil-pan into a glass "sump" graduate as shown in Fig. 5. The oil-pump suction was run from this sump graduate, making the latter act as an oil reservoir of very small capacity.

A third change was made in the water-jacketing of

the crankcase to control the crankcase temperature. A double-walled sheet-metal oil-pan was made with steep sloping walls for the rapid drainage of oil. Water is run into the space between the two walls, which are heated or cooled as desired.

TEST ROUTINE

A routine test consists of a 2-hr. run during which all the conditions selected for the particular run are held as constant as possible. In starting the engine, after the cylinder jackets and oil-pan have been brought up to the desired temperatures, 400 cc. of oil warmed to 100 deg. fahr. is put in the sump graduate under the oil-pan. A second graduate, but of 1000-cc. capacity, is filled with a reserve of warmed fresh oil and used to maintain the level of the sump graduate at the 400-cc. mark. After the engine is running steadily with all temperatures correct, an observation is made of the oil level in the sump graduate every 5 min. and a sufficient amount of fresh oil is added immediately to restore the 400-cc. level. This procedure, by which the oil consumption is determined by the addition of fresh oil necessary to maintain a constant oil-level, is repeated every 5 min.

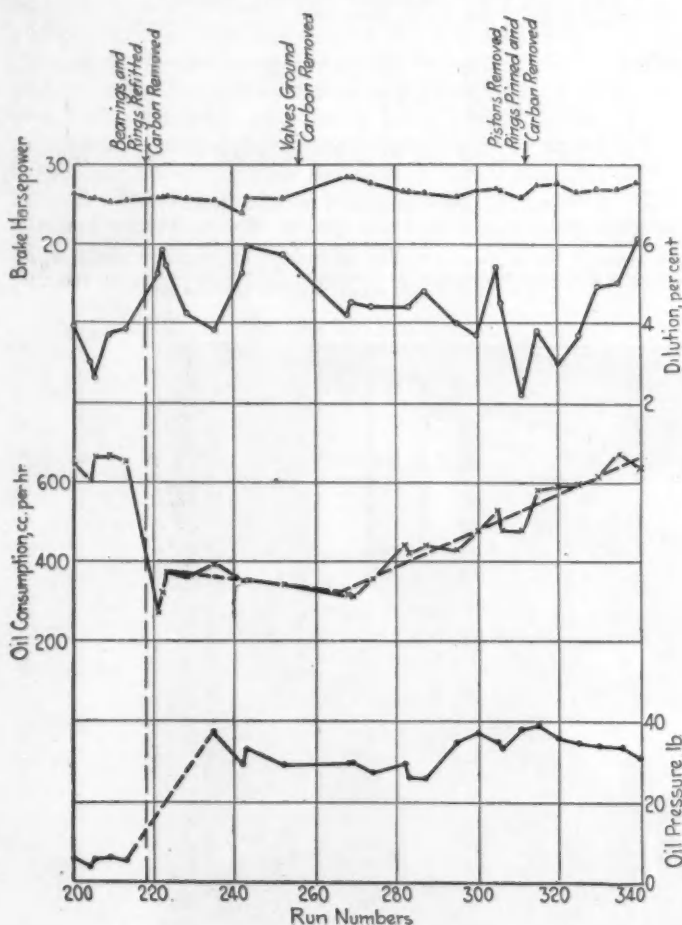


FIG. 7—EFFECT OF MECHANICAL CHANGES IN THE ENGINE AS THE TESTS PROGRESSED

The Curves Show the Power Developed, the Percentage of Dilution, the Oil Consumption and the Oil Pressure for a Number of Runs and the Work That Was Done on the Engine from Time to Time. The Oil-Consumption Line Is of Particular Interest as Showing a Practically Uniform Decrease for the First Part of the Tests and a Uniform Increase for the Runs after No. 267. The Pistons Were Removed after Run No. 311 and the Pins Holding the Piston-Rings in Place, Which Had Been Sheared Off in the Lower Ring-Groove of Each Piston, Were Replaced. This Seemed to Have No Influence on the Rate of Change in the Oil-Consumption Line

during the remaining 2 hr. of the run. Use of such a small volume of oil in the whole lubricating system, scarcely 1 qt., was expected to result in a more rapid dilution, but we believe that it does not affect the results otherwise.

The data secured are plotted for each run, where points for the 5-min. readings are indicated, of the total

oil drawn from the 1000-cc. supply-graduate, of oil pressure, of crankcase temperature and of engine torque. A plot of this kind is given in Fig. 6, which shows the customary regularity of the oil-consumption readings. The actual rate of oil consumption recorded for the run is taken from the slope of the straight part of the line. At the end of each run, a record is made of the oil drained from the crankcase when the engine stops, which records all the oil in circulation. After the viscosity is measured, the percentage of dilution is estimated from Fig. 3.

RESULT OF WEAR OF TEST-ENGINE

The first few runs we made showed some unexpected irregularities. Occasionally, the consumption line would be well developed at a certain slope and then suddenly change to a new slope without going through any curve to indicate a gradual transition. It was surmised that the piston-rings might be turning in their grooves until the slots came in line. Consequently, when the pistons were removed after run No. 217, the rings were pinned to prevent them from turning.

To record the effects of mechanical changes in the engine as the parts wore during the entire series of these runs, frequent checks were made under a set of identical conditions that were termed "standard runs." The results are given in Fig. 7, together with notes showing the mechanical work done on the engine in the meantime. The oil-consumption line is of particular interest on this chart, especially from run No. 230 onward. It consists of two distinct parts; the division is made by run No. 267. The first part shows a uniform decrease in oil consumption, while the second part shows a uniform increase. If the dotted line be considered the average and true value of this line, then the maximum error of any individual reading is not more than 10 per cent. After run No. 311, we removed the pistons and found that the pins used to prevent the piston-rings from turning had been sheared off in the lowest ring-groove of each piston. These were replaced but seemed to have no influence on the rate of change of the oil-consumption line of Fig. 7.

The period from run No. 221 to run No. 340 represents about 240 hr., or the equivalent of approximately 5000 miles of passenger-car operation and, while there has been but little road-dust in the laboratory to be the cause of much wear, the appreciable taper of the cylinders has caused the rings to work in and out in their grooves to a considerable extent. Meanwhile, the bearings have shown but little wear, as indicated by the fact that the oil pressure is well maintained.

The "standard" conditions referred to, under which these runs have been made, are stated in Table 1. Each series of runs was made by varying only one of these standard variables at a time; all others were held constant.

TABLE 1—"STANDARD" CONDITIONS OF TEST RUNS

Speed, r.p.m.	700
Load: Manifold Depression, cm. of Mercury	7
Spark-Setting, Degrees of Advance	35
Jet Number	55
Mixture Temperatures, deg. fahr.	
Carbureter Air	200
Cylinder Jacket-Water, Out	100
Oil-Sump Jacket, In	100
Resultant Crankcase Temperature	130 to 140
Fuel, Navy Specifications	Auto Gas
Oil	Pale Filtered
Oil Viscosity, Saybolt sec.	500

ENGINE-OIL DILUTION AND CONSUMPTION

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SERIES A—CARBURETER SETTING

Referring to Fig. 8, fuels and air-mixture ratio have a slight effect on oil consumption, but possibly more effect than is expected. The dilution, however, increases rapidly as the mixture is made rich. The ratio of dilution to mixture-ratio is fairly constant, so that doubling the fuel rate a little more than doubles the percentage of dilution. It is possible that the decreased oil-consumption resulting from a rich carbureter-mixture may be due to the increased fuel-content, for the oil-consumption figures have not been corrected for dilution. The dilution is not enough to account for the lowered consumption unless the dilution of the oil on the cylinder-walls may be considerably greater than that of the rest of the oil in the crankcase.

SERIES B—LOAD

Referring to Fig. 9, both the oil consumption and the dilution increase as the fuel consumption is increased by opening the throttle. The oil-consumption line drops

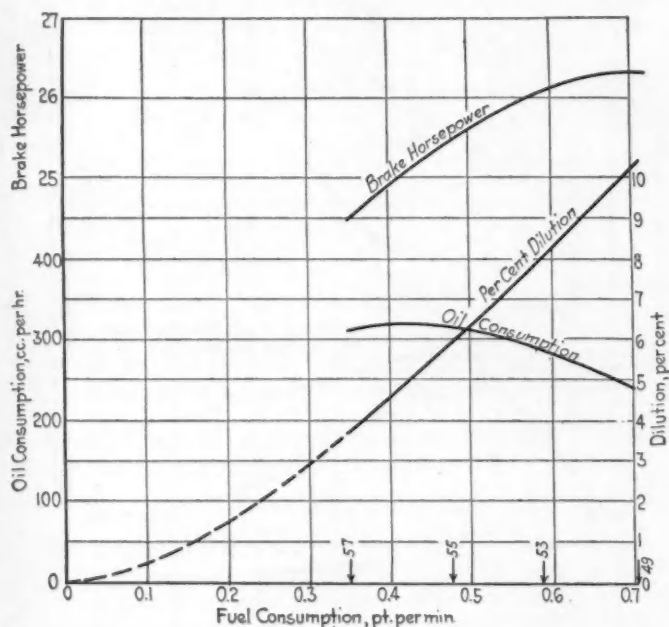


FIG. 8—EFFECT OF VARYING THE CARBURETER SETTING

In This Series of Tests the Dilution Increased as the Mixture Was Made Rich, the Ratio of the Dilution to the Mixture-Ratio Being Fairly Constant. The Decreased Oil-Consumption Resulting from a Rich Mixture May Be Due to the Increased Fuel-Content, But the Dilution Is Not Enough To Account for the Lowered Oil-Consumption unless the Dilution of the Oil on the Cylinder-Walls Is Considerably Greater than That of the Rest of the Oil in the Crankcase

a little as the dilution increases, for possibly the same reason as that offered in Series A.

It is of particular interest that the oil consumption increases in almost direct proportion to the fuel burned. This is possibly just what is needed, and it would seem that mechanical devices for this purpose are unnecessary.

SERIES C—OIL VOLUME

Referring to Fig. 10, by means of the change-speed gears driving the oil-pump, which were mentioned previously, we were able to vary the volume of oil passing through the bearings and thus to vary the volume reaching the cylinder-walls. It is seen that the oil consumption varies almost as a straight line with the oil volume, but that the pressure rises about as the square of the volume. Thus, if the volume be controlled by the oil pressure, the consumption will increase somewhat as the square root of the oil pressure. For a customary pres-

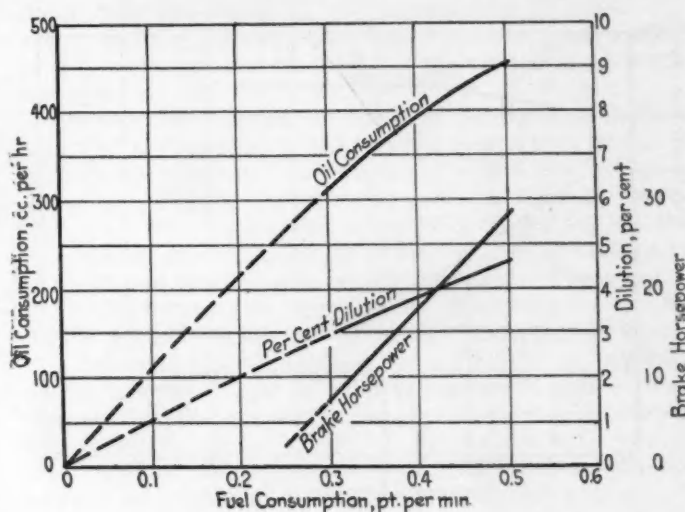


FIG. 9—EFFECT OF VARYING THE SPEED

The Oil Consumption and the Dilution Increase as the Fuel Consumption Is Increased by Opening the Throttle. The Oil Consumption Increases in Almost Direct Proportion to the Fuel Burned, But Falls off Slightly as the Dilution Increases

sure-lubricating system, this will hold, of course, only provided that the bearing clearances, oil viscosity and temperature remain the same.

With the oil consumption so completely under control, one naturally inquires what the consumption should be. This is a study outside the scope of the present investigation, though we have plans on foot to make a special study of that phase in the near future. For the present, our study includes only the quantity of oil actually consumed, not how much or how little should be consumed. Notice, however, that slightly lowering the oil consumption raises the brake-horsepower delivered, until the consumption has dropped to less than 200 cc. per hr., which is about 0.015 lb. per hp-hr. and not far from 1000 miles per gal. for a passenger car.

The dilution is seen to decrease as the consumption increases, as would be expected from the greater additions of fresh oil. This seems to explain the difference of oil dilution observed from our truck-tests reported in Figs. 1 and 2.

SERIES D—CRANKCASE TEMPERATURES

Referring to Fig. 11, no one variable has so great an effect on dilution as the crankcase temperature. With

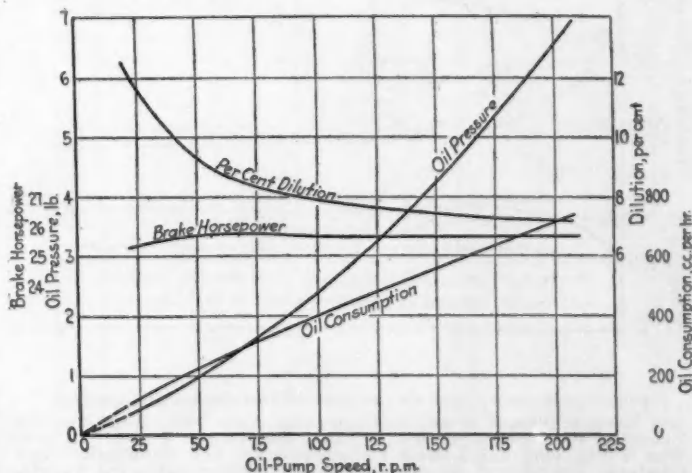


FIG. 10—HOW CHANGING THE VOLUME OF OIL AFFECTS THE DILUTION
The Volume of Oil Passing through the Connecting-Rod Bearings and Reaching the Cylinder-Walls Was Varied by Changing the Speed of the Oil-Pump. The Oil Consumption Varies Almost as a Straight Line with the Oil Volume, But the Pressure Rises Approximately as the Square of the Volume. The Dilution Seems to Decrease with an Increased Oil-Consumption

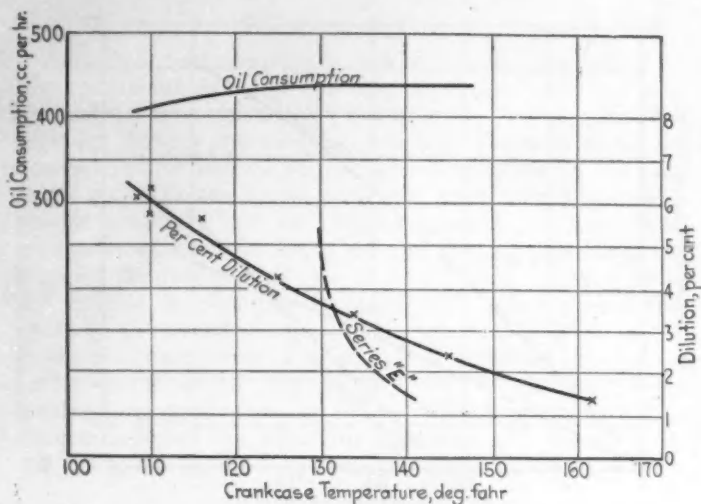


FIG. 11—EFFECT OF CHANGING THE CRANKCASE TEMPERATURE
This Variable Has the Greatest Effect on the Percentage of Dilution, an Increase of 35 Deg. Fahr., Reducing the Dilution by 50 Per Cent. The Shape of the Curve Shows That Dilution Probably Will Increase More Rapidly at the Lower Temperatures

our apparatus we are limited to a small range of crankcase temperatures, but an increase of only 35 deg. Fahr. results in reducing the dilution one-half. From the shape of the curve it is seen that the dilution may increase still more rapidly at lower temperatures. When one considers how cold a crankcase may be in winter after standing outdoors all night or even in an unheated garage, and that it normally requires 2 or 3 hr. of running to heat-up, it is easy to imagine that crankcase temperatures are normally cold enough to be in the region of high dilution. Furthermore, many engineers make a particular point of keeping the crankcase oil-temperature as low as possible by providing large ribbed oil-pan areas exposed directly to the air that blows under the car. On the other hand, anything done to keep the crankcase warm should result in less dilution. The data for Fig. 12 were secured to prove this contention. The results are given from two 7-hr. runs that differed from our regular runs only in their length and in the fact that the oil viscosity was taken every 30 min. We kept 100 cc. of oil out of the system for use in a Saybolt viscosimeter and, when we withdrew 100 cc. for a viscosity

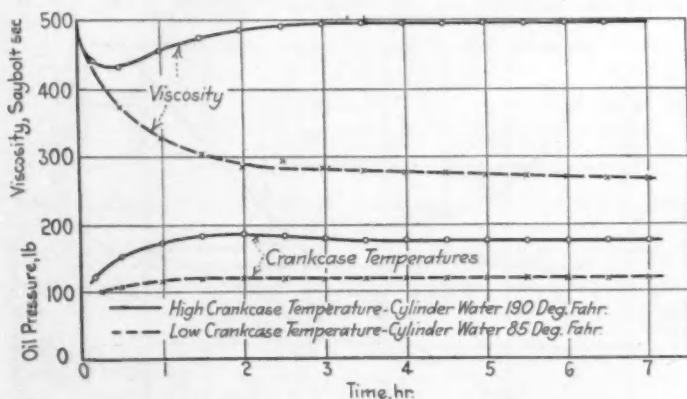


FIG. 12—KEEPING THE CRANKCASE WARM REDUCES DILUTION
The Results Plotted Were Obtained from Two 7-Hr. Runs and the Viscosity Was Taken Every 1/2 Hr. The Lower Viscosity Curve Was Taken with the Lowest Cylinder-Jacket and Crankcase Temperatures That Could Be Maintained and Corroborates the Results of the Road-Tests Plotted in Fig. 1. The Upper Viscosity Curve Was Taken at the Highest Cylinder-Jacket and Crankcase Temperatures That Could Be Maintained. It Shows That Dilution Can Be Practically Eliminated without Any External Devices. The Drop in the Viscosity in the Early Part of the Run and Its Subsequent Rise Follows the Crankcase Temperature and Emphasizes the Importance of the Latter

reading, we immediately returned the 100 cc. from the previous reading.

The curves are almost self-explanatory. The lower viscosity-curve was taken with the lowest cylinder-jacket and crankcase temperatures we could maintain. The shape is characteristic; it corroborates what we have found from our road-tests, shown in Fig. 1, and justifies our acceptance of a 2-hr. run as a close indication of the extent of dilution that will result from a given set of conditions.

The upper viscosity-curve was taken under the same conditions as those for the lower curve, except that the highest cylinder-jacket and crankcase temperatures we could maintain were used. No change was made in the carburetor temperature or in the mixture ratio. This curve shows that dilution can be practically eliminated without any external devices. The drop in the viscosity

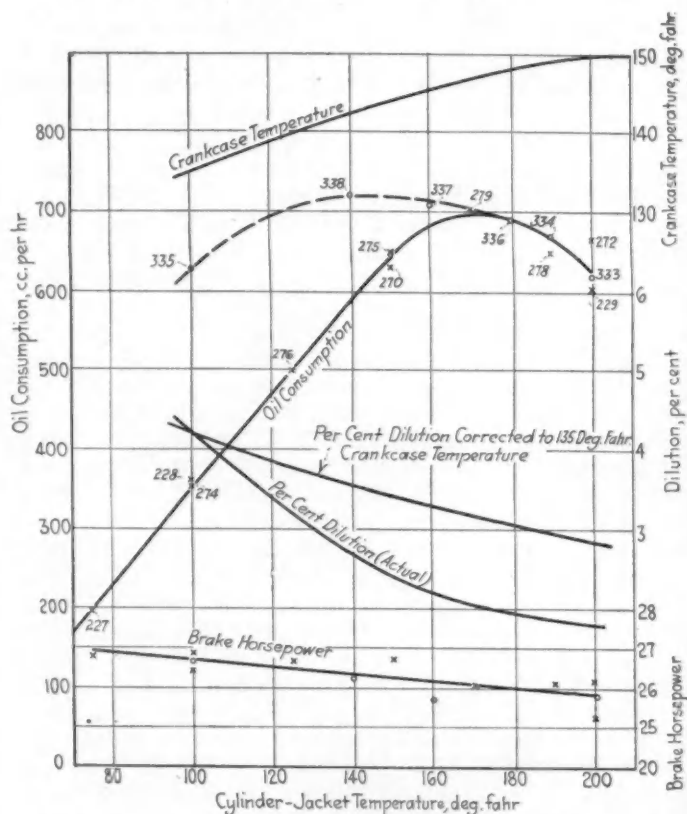


FIG. 13—EFFECT OF VARYING THE CYLINDER-JACKET TEMPERATURE
The Oil-Consumption Curves Were Obtained 3 Months Apart and the Difference in the Shape at the Lower Temperatures Should Be Noticed. The Falling Off in Power as the Jacket-Water Temperature Rose Is Interesting. This Cannot Be Attributed to a Change of Volumetric Efficiency Since the Same Carburetor Setting Was Used Throughout and the Rate of Fuel Consumption Did Not Vary Appreciably in Any Run

in the early part of the run, and its subsequent rise, follow the crankcase temperature and again emphasize the importance of the latter.

Further, the very small dilution observed ordinarily in dynamometer runs undoubtedly is due to their hot crankcase-temperatures. During oil tests we have witnessed in automobile manufacturers' plants, we have observed temperatures of more than 200 deg. Fahr.

CARBURETOR AIR-TEMPERATURE

We made several runs with air temperature of 100 deg. Fahr. at the carburetor instead of the normal 200 deg. Fahr., and were surprised to find no increase whatever in the resulting dilution. It does not seem that this can be due to a dry mixture, because we have found more

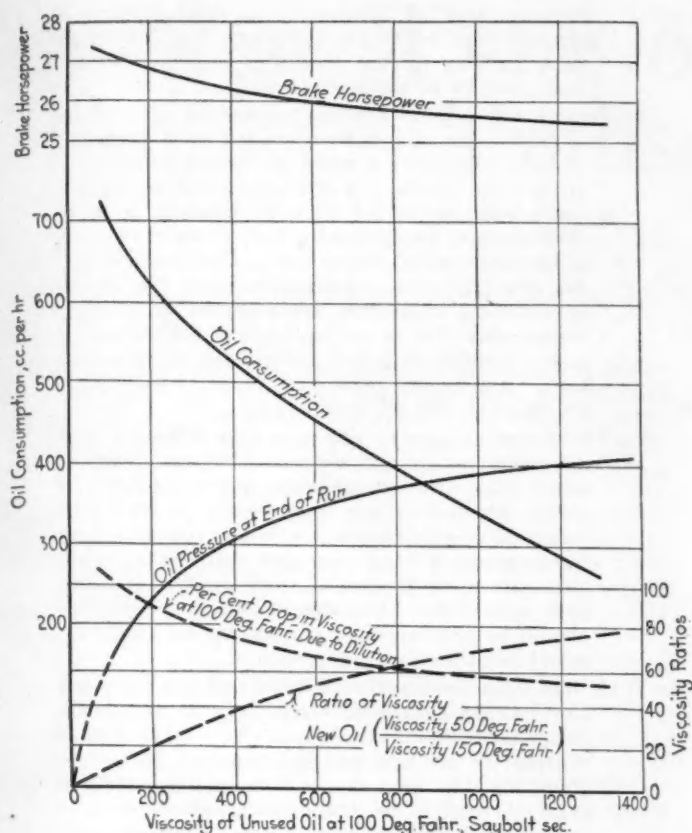


FIG. 14—EFFECT OF DIFFERENT VISCOSITIES

As was to be expected the oil consumption varied considerably with the viscosity, but the oil pressure did not increase with the viscosity as rapidly as expected because the high-viscosity oils lost a much greater proportion of their viscosity than the low-viscosity oils. The greatest power was delivered with an oil that had a viscosity of less than 40 Saybolt sec. at the cylinder temperature and 60 Saybolt sec. at the crankcase temperature.

than one-third of all the fuel going through the manifold to be unvaporized at this temperature.

SERIES E—CYLINDER-JACKET TEMPERATURE

Referring to Fig. 13, some of the data we secured in this series were of special interest. The tests were rerun completely 3 months later. The engine had to run more than 200 hr. in the meantime and, of course, it was not in the same mechanical condition. The oil-consumption curves developed at these two periods were of very different shape at the lower temperatures but seemed to become tangent at the higher temperatures. To enable the runs shown in Fig. 13 to be traced, the run numbers are shown opposite each point. Both curves revealed a well-defined peak.

Another feature of interest was the drop of power as the jacket temperature rose. This could not have been due to a change of volumetric efficiency, since the same carburetor-setting was used throughout and the rate of fuel consumption did not vary appreciably in any run.

SERIES F—OIL VISCOSITY

Referring to Fig. 14, we had available a series of five oils refined from substantially the same crude, but varying in viscosity from 100 to 1300 Saybolt sec. at 100 deg. Fahr. The oil consumption varied considerably with the viscosity, as was to be expected. The oil pressure, however, did not increase with the viscosity as rapidly as was expected, because the high-viscosity oils lost a much greater proportion of their viscosity from dilution than did the low-viscosity oils. Yet, had a pressure-regulating bypass been used to maintain the same pressure with all

these oils, the ratio of oil consumption between the lowest and the highest would have been about 4.3 instead of 2.7, although the ratio of oil viscosities is 13 when measured at 100 deg. Fahr.

The effect of dilution is shown as the ratio of the viscosity of the used oil to that of the new oil; it indicates a more satisfactory performance for the oils of lower viscosity. This is corroborated by two other curves in Fig. 14. One shows the effect of temperature on the viscosity of new oil in terms of the ratio of the viscosity at 50 deg. to the viscosity at 150 deg. Fahr. The other is the brake-horsepower curve, which shows a constant increase as the viscosity is lowered. The greatest power was delivered with an oil that had a viscosity of less than 40 Saybolt sec. at the cylinder temperature, and 60 Saybolt sec. at the crankcase temperature. No indication was found in our work that the lubrication with this oil was not entirely satisfactory, although the engine did not run as quietly as with the oils of higher viscosity.

SERIES G—ENGINE SPEED

Referring to Fig. 15, in this series we could not control the crankcase temperature at speeds above 800 r.p.m.; consequently, the dilution and the oil-pressure data had to be corrected. This is, of course, not very satisfactory in experimental work. The oil-consumption data are shown in Fig. 15, as well as a dotted curve that corrects the consumption to 700 r.p.m. By changing the scale, this curve would represent the oil consumption per revolution of the engine. The curve shows the same general shape as the one in Fig. 12 where the water-

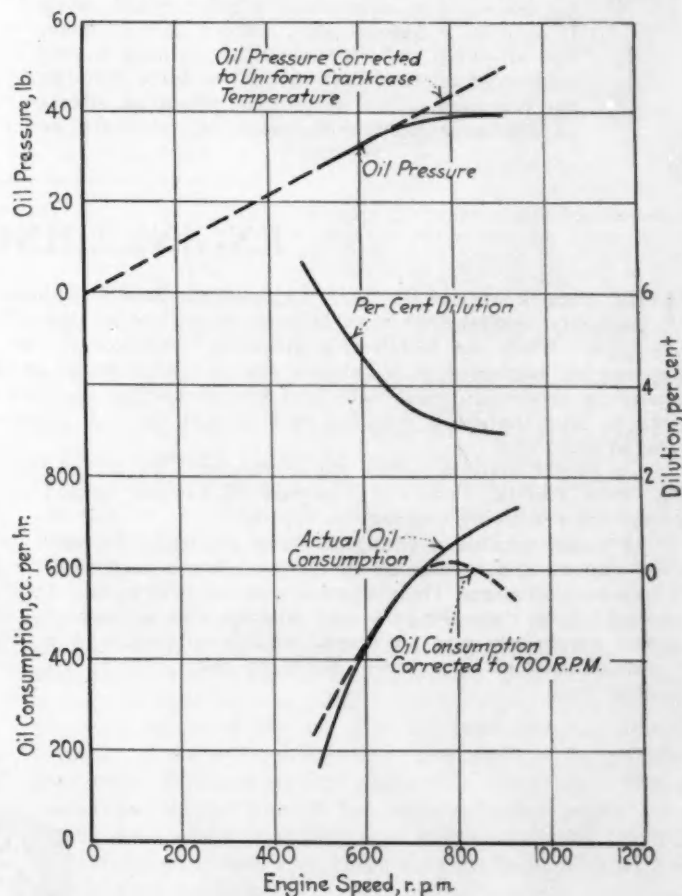


FIG. 15—EFFECT OF VARYING THE ENGINE SPEED

As the engine speed is increased the quantity of oil passing by the pistons is reduced even when the volume of oil splashed on the lower part of the cylinder walls at each revolution is maintained constant. To do this it will be seen that the oil pressure rises with the speed.

jacket temperature was varied. The crest this time is of greater importance because it indicates a constant reduction in the quantity of oil passing by the pistons as the engine speed is increased, even when the volume of oil splashed on the lower part of the cylinder-walls at each revolution is maintained constant. To accomplish the latter, it will be seen, the oil pressure rises directly with the speed.

SUMMARY

The data presented in this paper have been collected during the course of a study we are making in regard to the fundamentals of engine lubrication. It is not intended to be a complete answer, by any means, but we have felt that the general trend of results so far secured would be of interest to many engineers and that it may throw some light on some of the perplexing lubrication problems that confront them. It is, of course, a difficult matter to attempt to draw any conclusions from incomplete data, but a few features are indicated that are of sufficient importance to specify particularly

- (1) Crankcase dilution can be reduced to an unimportant factor by keeping the crankcase warm. High jacket-water temperature also assists in reducing dilution. Dilution is by no means a "breaking-down" or decomposition of the oil, and a badly diluted oil can be restored to its original viscosity by evaporation, as is shown by the upper curve of Fig. 12
- (2) An excellent lubricating system can be produced by eliminating the present function of the oil bypass-valve as a pressure regulator and using it only as a safety-valve. When this is done, the oil-pump capacity must be reduced to the volume of oil that it is desired to force through the bearings. This system, in which all effects of changing bearing-clearance, oil viscosity or

temperature are eliminated in their control of the oil supplied to the cylinders, has proved its practicability on the Mercedes and the Renault cars and in airplane engines

- (3) One of the reasons for the marketing of a series of motor oils of different viscosities is to supply a demand for the control of oil consumption to reasonable limits. If the consumption appears too great, an oil of higher viscosity is used; if it appears exceptionally low, a lower viscosity is not only satisfactory, but probably preferable for other reasons. Indirectly, then, the grades of different viscosities are resorted to so as to compensate for those mechanical differences in engine conditions which control the oil consumption. Almost the same results could be secured by varying the oil pressure
- (4) There are so many factors which influence both oil consumption and dilution that any tests in which they are not all recognized, at least, or preferably held under control, are of very little value. For this reason we do not feel that road tests in which crankcase and cylinder temperatures are unknown are of much analytical value; and, even when they are known, some method should be available for converting to a common set of conditions
- (5) It has been shown that the rate of oil consumption can be controlled completely in an engine, either by the oil viscosity or by adjustment of thermal or mechanical conditions of the engine. How far the oil consumption can be reduced safely is still to be determined, but we hope to throw some light on this question as our experimental work progresses. Suggestions as to phases of this study that are of particular interest will be very welcome to us and will assist us in carrying our work to an ultimate conclusion that we hope will be of real benefit to the automotive industry

ENGINEERING EDUCATION

THE outlook of the Harvard Engineering School is less narrowly professional than that of most institutions of the type. While the technical engineering problems of the day are not neglected, it is believed that a leader in the engineering profession must have laid his intellectual foundations so deep that he is qualified to deal with the new problems of tomorrow.

In a recent address before the Princeton Chapter of the Phi Beta Kappa, President Farrand of Cornell quoted a prominent practising engineer as saying:

I would take those young men and give them 4 years of physics and 4 years of chemistry, enough mathematics to understand their physics and chemistry, and I would give them English and history and economics and psychology and philosophy and languages, and I would waste no time on this thing we call technical engineering.

This is an extreme opinion, and few professors of engineering could be found to endorse it; but it is none the less significant of a tendency to redefine the object of higher engineering education. According to this view, its best product will be not a man already experienced in the detailed processes of industry, but a man well-grounded in the fundamental principles and with such resourcefulness and flexibility of mind as will enable him to cope with the unpredictable needs of a swiftly changing world. It is this kind of engineer who will be very well qualified for constructive leadership.

The need of the engineer in business and of the business man in engineering is growing. The relation between commerce and technology is becoming increasingly intimate, and it is proper that this relation should be established in training and education as well as in practice.—*Harvard Alumni Bulletin.*



A New Type of Constant-Mesh Transmission

By W. A. McCARRELL¹

SEMI-ANNUAL MEETING PAPER

Illustrated with DRAWINGS

GEAR-SHIFTING has been one of the great drawbacks of automobile operation since the days of the first sliding-gear transmission, especially to those persons who look upon the car as a means of transportation and want to go somewhere and return with the least amount of physical or mental effort. The number of persons who can shift gears satisfactorily either up or down in a clean manner is very limited. Heavy rotating parts that have a fly-wheel effect and clutches that do not release freely but have a dragging action work to the disadvantage of the ordinary driver and may be the cause of accidents.

The solution of the problem seems to be some type of transmission in which the various reductions can be engaged in any reasonable sequence when shifting either up or down and in which the effects of dragging and the momentum of the rotating parts are reduced to the minimum. Such a transmission must also be simple of construction and be capable of being manufactured economically. It should not contain any radical type of construction but should allow the driver to continue with greater ease his general habits of driving.

The friction type of transmission has been practically discontinued owing to its disadvantages, and many types of constant-mesh transmission that have been introduced have been successful or otherwise according to the methods by which they performed their functions and the amount of noise produced.

The type of constant-mesh transmission described in this paper, while resembling the conventional three-step-and-reverse type, differs from it in that slip collars rather than the gears on the upper shaft are moved to engage the various reduction sets. Details of construction are given and views are shown of both the helical and the spur-gear types.

Among the characteristics of the constant-mesh type of transmission under discussion are said to be ease of gear-shifting under any conditions, combined with a high degree of quietness of operation; a simplicity that allows it to be manufactured economically; and a flexibility that is obtained with very little divergence from conventional designs.

EVER since Levassor installed his first sliding-gear transmission, which he regarded as an expedient, the problem of changing speed has engaged the attention of automobile engineers. So long as automobiles were driven by persons who were mechanically inclined or who studied and adapted themselves to the details of the new fad, this particular phase of car construction was not particularly troublesome, or at least no more so than several other details. The automobile, however, has become a commodity and must meet the requirements of broad distribution to all classes of drivers, most of whom, instead of being enthusiasts, look upon the car as a means of transportation and want to go somewhere and return with the least amount of physical and mental effort.

Gear-shifting, as related to the various types of slid-

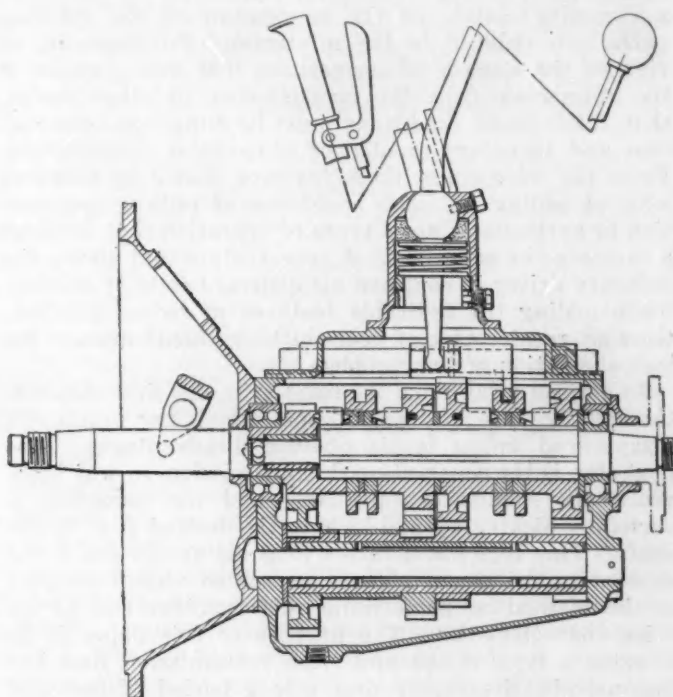


FIG. 1—THE SPIRAL GEAR TYPE OF CONSTANT-MESH TRANSMISSION This Transmission Greatly Resembles the Conventional Three-Speed-and-Reverse Type, the Gears Being Arranged in the Same Order from Front to Rear and the Reductions Obtained through a Step-Down Gear at the Front End. Although the Shifting Is Accomplished by the Usual Hand Lever Mounted in a Spherical Bearing or Mechanical Shift, Slip Collars Rather than the Gears on the Upper Shaft Are Moved To Engage the Various Reduction Sets

ing-gear transmission, has been one of the great drawbacks, leaving something to be desired by all but the most expert drivers. Those who can shift from low gear to high with any degree of uniformity and quietness are in the minority and, in spite of the known advantages of the engine as a brake in hilly country, very few persons have any luck in shifting to the next lower reduction while the car is moving at an appreciable speed. This condition is not caused altogether by the character of the drivers but is almost entirely chargeable to the inherent characteristics of sliding-gear transmissions. Some manufacturers have partly alleviated this condition by using clutches having very light rotating members, but the momentum of the gears in the transmission, plus the number of contacting points at the tooth ends, prohibits any great advance in this particular direction. The so-called double-shift must be utilized under many conditions, even when the latter case holds good, and the number of persons who can make this shift in a clean manner is very limited.

In many designs, the clutch also plays a part in detracting from the ease of gear-shifting. Heavy rotating members on the clutch shaft set-up a flywheel effect that reduces the possibility of bringing the upper and the

¹ Mechanical engineer, Milwaukee.

lower transmission shafts to anything like corresponding velocities at the pitch-circles, and therefore make shifting difficult, particularly in shifting back. In other cases, the clutch does not release freely and causes a dragging action that sets up a more extreme effect than do heavy rotating parts. All these things work to the disadvantage of the ordinary driver and may be responsible for accidents or prevent an otherwise satisfactory car from fulfilling its full measure of service.

The solution of these difficulties seems to be some type of transmission in which the various reductions can be engaged in any reasonable sequence when shifting either up or down; also, a transmission in which the effects of a dragging clutch, or the momentum of the rotating parts, are reduced to the minimum. Furthermore, in view of the element of competition that now prevails in the automobile field, the transmission, or other device, that fulfils these conditions must be simple in construction and therefore capable of economical manufacture. From the sales angle, these features should be obtained without adding the sales resistance of radical construction or particularly novel types of operation that involves a campaign of education. A construction that allows the ordinary driver to continue his general habits of driving, while adding the desirable features of better handling through greater ease of gear-shifting, should present the logical solution of this problem.

In getting away from the clash gear, the first step was the friction type of transmission, which has practically disappeared owing to its obvious disadvantages. The next step is the constant-mesh transmission, in which the gears are engaged at all times and the reduction is varied by picking up and locking the desired gear to the shaft. This type has a rather long history in which the element of failure or success is related almost entirely to the method of performing this function and to its noise characteristics. The purpose of this paper is to describe a type of constant-mesh transmission that has demonstrated its ability over a long period of test and road work and combines silence with ease of operation and production.

DESCRIPTION OF THE TRANSMISSION

The McCarrell constant-mesh transmission, as illustrated by Fig. 1, resembles the conventional three-speed-and-reverse type, in that the gears are arranged in the same order from front to rear, and reductions are obtained through step-down gears at the front end, which in turn drive a lower shaft fitted with fixed gears that engage with corresponding gears on the tail-shaft. Although shifting is accomplished by the usual hand-lever mounted in a spherical bearing or mechanical shift, slip collars rather than the gears on the upper shaft are moved to engage the various reduction sets.

Again referring to Fig. 1, the desired type of conventional clutch is mounted on the outer end of the shaft at the left, which carries an integral step-down pinion and a roller cage at its inner end. A two-row annular ball-bearing is shouldered against the forward side of the step-down pinion and is restrained by a cap that is threaded at its bore to act as an oil-retainer. The tail or main shaft is centered in the clutch shaft by a Hyatt roller-bearing, and the end-thrust of the propeller-shaft is transmitted to the two-row bearing at the front by an assembly of three balls and a hardened disc. The main shaft is supported at its rear end by a single-row ball-bearing that is also restrained by another threaded cap. The main shaft is machined with three longitudinal recesses which leave three outstanding keys or lands, and

all the reduction gears revolve freely, being centered on the outer diameter of the keys. Each of the gears on the main shaft and the step-down pinion, which is integral with the clutch shaft, are made with an extension at the hub. As the parts leave the lathe, the dimensions of the hub extensions are $2\frac{3}{8}$ in. in diameter and $\frac{7}{8}$ in. in length. Before hardening, these extensions are milled to form three equally spaced slots, thus leaving six jaws. These slots with retaining rings, which are bolted into place at the outer end of the hub extension, form the cages for the roller clutches that are a part of each change-gear. Taper-sided cups are countersunk into the body of the gear at the bottom of the slots to receive and retain the extensions on the ends of the rollers. Similar cups or fully turned grooves are also machined on the inner sides of the retaining rings for the same purpose. This construction is varied in some cases by eliminating the projections on the end of the rollers nearest to the body of the gear and counterboring with a larger cutter, so that the barrel of the roller itself extends into the depression and acts as a retainer at the inner end.

In the type shown in Fig. 1, helical gears are used throughout; bronze thrust-washers are required, therefore, between each pair of gears and the clutch assemblies. These washers are $\frac{3}{16}$ in. thick and of the same diameter as the outside of the roller cages. The upper shaft assembly, from end to end, is assembled with about 0.01 to 0.02-in. end-play, and the bronze thrust-washers carry the end-thrust while the unit is idling. When any pair is engaged and transmitting power, the friction at the smaller diameter at which the rollers are interspersed between the shaft and the gear is sufficient to overcome the end-thrust of the helical teeth, and thus eliminates the possibility of undue wear. Furthermore, the helix angle is designed so that any possible resultant end-thrust is directed forward on the two-row bearings.

OPERATION OF THE TRANSMISSION

In operation the engine clutch is disengaged in the usual manner and the gear-shift lever is immediately directed to the desired position. By means of intermediary gate-rods and forks, this action moves a shifter collar over the hub of the proper gear. As indicated, this collar is chamfered at both ends of the bore. After about $\frac{1}{8}$ -in. motion of the collar, this chamfered surface contacts with the three long rollers of the roller-clutch in the extension of the gear-hub and forces them down into the depressions between the keys. By picking up the alternate or long rollers in this manner a distance of approximately 1 in. is allowed for the entrance of the roller into its proper depression. As the roller diameter is $\frac{9}{16}$ in., and the section of the cage is $\frac{7}{16}$ in. thick at this point, the rollers are forced in $\frac{1}{8}$ in. Further motion picks up the short rollers and engages them in a like manner. The motion of the collar continues then until the barrels of the rollers are completely covered and the collar is stopped by the lock-plug at the gate-rod.

In this position, three long rollers act as the driving members while the three short rollers take up the backlash. A clearance of 0.002 to 0.003 in. is allowed between the bore of the gear and the top of the splines, both of which are ground to size. As the drive is distributed at three points, the gear is centered on the driving rollers and is capable of flotation to compensate for distortion or for teeth that are not entirely perfect in contour. This centering feature is an important aspect of this transmission and will be dealt with at greater length in the discussion of the spur-gear type.

The rollers, shifting collars and main shaft are made

of S.A.E. No. 2335 Steel and pack-hardened, while all the gears are made of S.A.E. Steel and oil-treated.

Roller clutches of this type, which is one of the distinctive features of this transmission, have been used extensively in marine work for reversing gears in which no friction-clutch is included. Shifting under these conditions is accomplished with entire satisfaction; the direction of the propeller with its inertia load can be reversed instantaneously. A test car has been driven for more than 1000 miles with but one roller in each gear. This test was extremely severe as the allowable backlash between the shaft and the respective gears set-up undue conditions of impact. The same construction, which was devised 6 years ago, is now being adopted for the change-gear boxes of machine tools, with no related friction clutches.

Fig. 1 illustrates the helical-gear type of transmission, in which the faces of the teeth are 1 in. wide. The normal pitch in this case is 8 and the helix angle is 25 deg., the teeth being of standard form of 20-deg. pressure-angle. Some compromise between the helix angle and the tooth face was required to ensure an overlapping effect. As the end-thrust resulting from the 25-deg. pressure-angle is not great, this figure was combined with the 1-in. width to allow a slight overlap. All the gears on the upper shaft assembly are cut with spirals of the same hand so that the rearward thrust of the step-down pinion is more than offset by the greater thrust of the engaged gear on the main shaft because of the greater pressures developed through the reduction process. All end-thrust loads are therefore transmitted to the two-row bearing at the front end.

ADVANTAGES CLAIMED

An unusual degree of silence is obtained with the helical type of transmission, which, combined with the feature of easy shifting, made this type most attractive until it was discovered that the same features were present in the plain spur-gear type with the added advantage of greater simplicity and shorter overall length. As the face of the helical gear is somewhat greater than is required to obtain overlapping teeth, the width of spur gears can be reduced from $\frac{3}{8}$ to $\frac{1}{2}$ in. to carry the same power. Furthermore, the bronze thrust-washers of which there are three can be eliminated entirely. The overall length of the transmission can therefore be reduced 2 9/16 in. in all.

Fig. 2 illustrates a spur-gear type of the same capacity as shown in Fig. 1. The compact appearance of this type is readily discernible. It must also be remembered that the weight is correspondingly reduced. At first thought it would seem that a gear width of $\frac{1}{2}$ to $\frac{3}{8}$ in. is insufficient, but this dimension is explained by the fact that no chamfers are required on the ends of the teeth to allow engagement of the gear. The average gear for a transmission of this size, 80 hp. maximum, is about $\frac{7}{8}$ in. wide and the effective contact-face is reduced by as much as $\frac{1}{4}$ in. in some cases by the chamfers at the ends of the teeth. Naturally the width of the face must vary to some extent with the size of the engine; a transmission like that shown in Fig. 2, however, has shown excellent performance for more than 50,000 miles in a Stearns-Knight phaeton, after being subjected to all sorts of "stunt" driving, in addition to a large amount of roadwork in sandy country.

After ease of gear-shifting, quietness is the most important factor in constant-mesh or other types of transmission. Although Fig. 2 represents a plain spur-gear type, in which the gears, of S.A.E. No. 2345 Steel, are

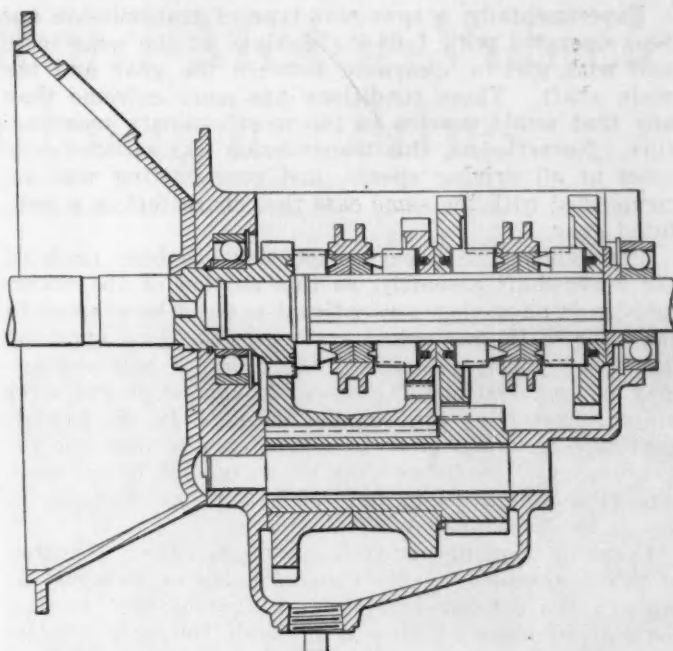


FIG. 2—A SPUR GEAR TRANSMISSION OF THE CONSTANT-MESH TYPE AS NO CHAMFERS ARE REQUIRED ON THE ENDS OF THE TEETH TO ALLOW ENGAGEMENT OF THE GEAR, A COMPACT CONSTRUCTION AND A CORRESPONDING REDUCTION IN WEIGHT ARE SECURED. A TRANSMISSION OF THIS TYPE HAS GIVEN EXCELLENT PERFORMANCE FOR MORE THAN 50,000 MILES IN A CAR WHERE IT WAS SUBJECTED TO STUNT DRIVING AND ROAD WORK IN SANDY COUNTRY

not ground but oil-hardened, its characteristics as to quietness may be demonstrated by the fact that it has been necessary to put friction springs behind the rollers in some of the clutches. The job was exceedingly quiet at all speeds, with one exception, which is explained as follows. An unusually low gear-reduction, approximately 4 to 1, was installed, and a click developed at low car-speeds when in direct drive. Upon investigation, this click was found to be caused by the rollers in the low gear dropping into the depressions in the main shaft as they passed over the top center. The speed was sufficient to develop enough centrifugal force to keep the rollers in all the other cages in the outer position while disengaged, but, on account of the high reduction, the speed at this particular gear was low enough to allow the rolls to drop. When a factor of this slight nature enters into the noise characteristics of a gearset, its quietness otherwise is pretty well demonstrated.

The smooth running and lack of noise in the spur-gear type must be attributed to the balanced drive at three equidistant points by the three rollers of each clutch. Some clearance must be allowed between a shaft and a free-running gear. If this gear is then driven at but one point when carrying a load, it is bound to be forced into an eccentric position toward the side where the driving-key is located. This action caused an alternately tight and loose condition at the point of engagement of the two gears and noise of an unpleasant nature would follow. In the case of the design shown here, the gear is centered on the three driving rollers and, furthermore, is allowed a sufficient amount of flotation to compensate for teeth that are a shade oversize. Normally, when driving, the gear rides on the rollers with the line of the driving-thrust through the rollers away from the radial direction. If any tendency toward tightness is indicated between engaging teeth, the rollers are forced down key-faces of the main shaft to a corresponding degree and the teeth pass one another with no evidence of jamming and noise.

Experimentally, a spur-gear type of transmission has been operated with 1/64-in. backlash at the gear teeth and with 0.01-in. clearance between the gear and the main shaft. These conditions are more extreme than any that would develop in the most ordinary manufacture. Nevertheless, this transmission was satisfactorily quiet at all driving speeds, and gear-shifting was accomplished with the same ease that characterizes a well-fitted gear.

Throughout this paper no mention has been made of the lower-shaft assembly, as this portion of the transmission is altogether conventional and can be adapted to the ideas of the individual engineer, depending upon the degree of quality desired. Plain roller or ball-bearings may be installed and the assembly can be forged as a unit or broken up into smaller details. In the helical-gear type the latter process is necessary to meet the requirements of manufacturing economy, but in the spur type either method may be used to suit the characteristics of the individual shop.

Economy of manufacture is one of the salient features of this transmission. No unusual parts requiring elaborate equipment are involved. Milling of the jaws at the ends of the gear hubs is probably the most complicated operation in the whole assembly. This operation can be performed with great accuracy and speed in an ordinary horizontal milling-machine by using three cutters on the arbor and a six-station rotary indexing fixture. A completely finished jaw comes off the machine each time the fixture is indexed. The rollers, short and long, retainer rings, shifter collars and, if desired, some of the gears can be made in automatic screw-machines. No grinding is required on the rollers or recessed portion of

the main shaft, and the shifter collars are ground on the inside only. To a certain extent the cutting of the jaws in the gear is offset by the broaching and chamfering requirements of the usual gear layout. In addition to these advantages, gear-grinding can be eliminated from the manufacturing scheme. In the design shown in Fig. 2 the low and reverse gears are identical.

SUMMARY

Summing up the characteristics of this transmission, it may be stated that the desirable features of easy gear-shifting under any conditions are combined with a high degree of quiet operation. Gear-shifting is performed in the conventional manner or, if desired, the ease of gear-shifting will allow the use of any of the better known means of mechanical gear-shifting. In addition to these features, the use of which is either prohibited or confined to limited successful operation with the sliding-gear type of transmission, the simplicity of its various parts allows it to be manufactured on an economical basis. The latter feature is of prime importance in the consideration of any new development, when the highly competitive condition of the industry is remembered. As regards the former, the thought and publicity that have been given to devices that replace the sliding-gear type indicate that public appreciation and demand for a better means of varying the reduction between the engine and the rear axle are imminent. The fact that this broad flexibility is obtained with very little divergence from present conventional designs has a natural appeal from both the engineering and the manufacturing viewpoints. This is just a step in the program of designing motor cars having greater utility for the ordinary citizen.

MECHANICAL CONSTANT-TORQUE VARIABLE-SPEED TRANSMISSION

(Concluded from p. 92)

that the average engine is run most of the time so as to develop only from one-sixth to one-third its load capacity.

USE OF LIGHTER ENGINE

The Weiss transmission also opens the way to a material reduction in the weight of the engine, because of its ability to produce infinite speed-reduction and, therefore, infinite leverage. Even though the engine when coupled to this transmission is developing only slightly more power than that required to overcome the friction of both units, it is capable of moving the driven element. Otherwise the failure of the element to yield will result in the breaking of the weakest link in the mechanism. An engine of sufficient power to run a vehicle on ordinary roads and on direct drive at any maximum speed desired, has therefore all the power necessary, because, as the engine can slip the wheels at the proper speed-ratio position, the vehicle can climb any hill within the friction-coefficient of the wheels to the road. And, moreover, when the vehicle must be run up a very steep grade, or must pull out of a ditch or snow-bank, for instance, a much better traction is obtained at an extremely low speed-ratio with a correspondingly enormous torque, than when, with a step-speed transmission, a clutch must be thrown in at a fixed speed-ratio many times higher.

The internal-combustion engine has no torque at zero speed. Since speed of rotation gives both torque and

velocity, the speed becomes the largest factor in the horsepower figures. The steam engine has no such handicap because it has 100-per cent torque at zero speed, which gives it complete flexibility within its pressure limits. The internal-combustion engine, equipped with the Weiss transmission, surpasses the action of the steam engine in this respect. The flexibility of the internal-combustion engine equipped with this transmission goes beyond its pressure and speed limits, because its torque can be increased in an automobile or locomotive, for instance, to the point of slippage.

The adaptability of the transmission to automatic control through the use of a torque governor has already been mentioned. Several types of torque governor have been designed and such a governor may be placed on the propeller-shaft so as to react on the speed-control members and thus vary the transmission-ratio with the variations of resistance to motion encountered by the driving-wheels. The speed of the car is then still regulated by the accelerator, and when the accelerator is released and the engine allowed to idle, the transmission comes to the neutral position and the car is locked against motion.

No limit is imposed upon the horsepower capacity to which the Weiss transmission can be built. And as the torque capacity increases as the cube of the diameter, the size, weight or cost does not become excessive as the capacity of the transmission is increased.

Building-Arcades Afford Motor-Vehicle Loading and Parking Facilities

By MAJOR F. S. BESSON,¹ U. S. A.

Illustrated with PHOTOGRAPHS

WHEN the arcading of a building in the manner shown in Fig. 1 is suggested to a business man, he is likely to reply: "No indeed, that land is worth \$50 per sq. ft. One truck would occupy space worth \$4,500." The reply is but partly true. It must be remembered that probably six to eight stories of the building are still above such an arcade, and that their serviceability is in no wise curtailed by it.

On a roadway prescribed for free passage of vehicles between those parked at the curb and the street-cars, if a truck is permitted to back up to the curb to load or unload it blocks the entire traffic on that side of the street. When the truck can occupy an arcade, as in Fig. 1, the roadway is left open for traffic, the sidewalk is not obstructed and labor is eliminated that otherwise would be necessary in carrying freight back and forth across the sidewalk.

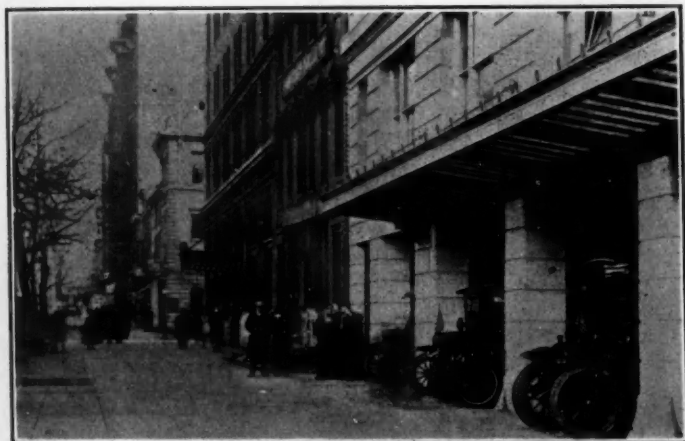


FIG. 1—HOW USING A BUILDING ARCADE HELPS TRAFFIC AND OTHER CONDITIONS

Providing Space behind the Building Line for Trucks Leaves the Roadway Open for Traffic, Keeps the Sidewalk Free from Obstructions and Eliminates the Labor That Would Otherwise Be Required To Carry Freight Back and Forth across the Sidewalk

In congested areas, the anomalous situation may exist in which but one-way traffic is available at times, as shown for F Street, City of Washington, in Fig. 2. Motor cars are parked diagonally at the curb on both sides of the street, which is 60 ft. wide. A car at the left hand stopped and is without a driver, the assumption being that he has entered some building on business. Another car stops at the right to allow a passenger to alight; it must stop out in the street and thereby closes one lane of traffic. Every car in dead storage shown in Fig. 2 is occupying \$4,000 to \$8,000 worth of space. A

¹ Acting engineer-commissioner of the District of Columbia, City of Washington.



FIG. 2—WHAT SOMETIMES HAPPENS IN CONGESTED AREAS In This 60-Ft. Street Traffic Can Only Move in One Direction because Cars Are Parked Diagonally at the Curb on Both Sides of the Street; a Car at the Left Has Stopped, Presumably To Make a Delivery; and a Second Vehicle at the Right That Has Stopped To Permit a Passenger To Alight Is Compelled To Halt in the Middle of the Street and Thus Ties Up Traffic in One Direction

somewhat similar situation is shown in Fig. 3 for 15th Street, City of Washington, which is 50 ft. wide. For the congested business heart of a city, is it better to put the overhead space to work to earn money as shown in Fig. 1, or is it better to set aside 45 per cent of the land area for streets and then permit half that overly generous street space to be used for garage purposes?



FIG. 3—ANOTHER EXAMPLE OF THE WASTE CAUSED BY PERMITTING MOTOR VEHICLES TO PARK AT THE CURB

In This View of a 50-Ft. Street in the City of Washington, Every Car at the Curb Is Occupying Space That Is Valued at from \$4,000 to \$8,000



Discussion of Papers at the 1924 Annual Meeting

THE discussion of three of the papers presented at the Production Sessions of the 1924 Annual Meeting included written contributions submitted by members and the remarks made at the meeting. In every case an effort has been made to have the authors of the several papers reply to the discussion, both oral and written, and these comments, where received, are in-

cluded in the discussion. For the convenience of the members, a brief abstract of each paper precedes the discussion, with a reference to the issue of THE JOURNAL in which the paper appeared, so that members who desire to refer to the complete text as originally printed and the illustrations that appeared in connection therewith can do so with a minimum of effort.

FLEXIBILITY IN HANDLING PRODUCTION MATERIAL

BY A. A. BROWN¹

COMMENDING the service of supplies of the Allies during the war as an example of the successful operation of a flexible distributing system and comparing the problems of a modern factory to a small army operating on a very active front, the author describes a simple, elastic and practical method of effectively handling materials that is in vogue throughout the various units of a large automobile factory. Like that of most other plants, the system under discussion has been developed by a process of evolution since the time when the layout consisted of a single small building with the departments adjacent to one another and has been gradually extended to cover the ramifications of widely separated units.

With elasticity as the keynote of the system, the stockrooms are scattered and the materials are placed promiscuously throughout the plant near the places of their consumption in as large quantities as possible. Those in charge are allowed to use discretion as to the routing and to decide which parts are to undergo thorough inspection and which ones may be sent direct to the points of assembling. If the needs of production demand it, material may be hurried through the inspection department or an inspector may follow it to the assembling line.

Material is transported by electric or motor trucks. Hand trucking is not permitted except in otherwise inaccessible places. Gravity conveyors are used extensively. Materials are held in the stockroom only because it affords a place in which to store large quantities and because it minimizes the possibility of theft of parts that function equally well on cars of other makes. Service-department requirements are supplied directly from production stock, which is replaced when it becomes materially decreased; a perpetual inventory is not kept, as it is considered cumbersome and expensive, defeating its own purpose and slowing up the delivery of material. One of the functions of such an inventory is filled by a shortage report that is made out when notice has been received from a stock-clerk or a foreman that the quantity of any part is getting low. An advantage of maintaining low stocks is that, if changes are made in parts, the new parts can be substituted quickly without waiting for a large stock of old material to be used up. The only stock records kept are those of the purchasing department, to which the stock department has access and which it assists in compiling. Stock-chasers go through this list each

day to determine whether the material received is up to specifications and whether a shortage is likely to arise. By analyzing the men and carefully selecting the personnel of the material-distribution division flexibility is capitalized and adaptations to changing conditions are quickly made. [Printed in the February, 1924, issue of THE JOURNAL.]

THE DISCUSSION

CHAIRMAN K. L. HERRMANN:—Has the chief inspector charge of assembling the final car?

A. A. BROWN:—No. The foreman is directly responsible to the chief inspector if the car is not assembled correctly. The chief inspector takes it upon himself to go through the plant every day, or as often as he can, and look over the car very much in detail.

W. A. STARCK:—What records has the foreman? What material is in his department?

MR. BROWN:—He does not know what material is in his department. He sees it all there. He keeps no record of materials whatsoever, unless he chooses to do so of his own volition. The stock is simply placed on his line. I do not know whether I laid sufficient stress on the point that in the plant it is to the foreman's interest, and to the interest of every man who works for that foreman, to have enough material on the line to keep going. If material is lacking he loses time. Therefore, they all take it upon themselves to see that the material is there; they set an alarm long before the material is actually short, because a large amount of piecework is done in the plant and if the material is lacking they cannot go on with the work. But the foreman keeps no records unless he does so of his own free will.

QUESTION:—Did I gather correctly that you do not place much confidence on packing slips?

MR. BROWN:—Packing slips are used as a matter of comparison. The packing slip, however, is not really a final authority for the number of pieces that we actually receive, although we do not consider that we are dealing with any unscrupulous firms. We maintain that the number of pieces as checked into the plant by our checker is the number of pieces that we pay for, and, even if the number on the packing slip should be different from ours, the check that we get determines the number for which we pay. The packing slip may have been correct when it left the vendor, and some of the parts may have been

¹ Stock manager, Chandler Motor Car Co., Cleveland.

lost on the way. We pay for only the number of parts received.

QUESTION:—Do you find many discrepancies between the packing slip and your actual count?

MR. BROWN:—We do. However, in the scale counting of material, you must concede a certain commercial tolerance. If it is within these limits, we do not say anything.

QUESTION:—How do you keep a record of what you have ahead for production? Who has that record, the production department, the receiving department, or the purchasing department?

MR. BROWN:—As it is maintained, I believe the record is a departure. I personally have never seen anything exactly like it. We have a composite form used by the purchasing, the stock and the production departments on which is kept a record of the receipts, with the receiving ticket number and the date of receipt. In the first few columns on the sheet we record the receiving ticket, namely, the quantity on the receiving ticket, the date of the receipt and, as I said before, all the features that enter into the receipt of that material. On this same form a record is kept of the invoices, together with the totals for which we are invoiced. If they have not been billed correctly, then we note the difference between the receiving records and the number of pieces for which we have been invoiced. That invoice record reports the number of pieces and not the cost of the material. If the records correspond, of course, everything points to their being correct.

We supply the service department from the regular material in the plant for the current model. That diminishes the material on hand rather greatly sometimes. Then we also deduct scrap. From the bill of material, we can tell how much material should be used on each car and, knowing how many cars have been built, it is a simple calculation to find out how much material has been used in production.

We will suppose the production at the present time has reached 18,000 cars and the records show that enough material for 19,000 is in the plant. You can see then, theoretically at least, that you have a margin of material on hand for 1000 cars. You must keep in mind, however, that the actual shortage is reported by the men in the plant, by the foremen and by the assistant stores manager who actually checks the material on hand, so that, if shortages do arise, they are detected early enough to be taken care of.

QUESTION:—Do you check your services each day?

MR. BROWN:—Every time the service department gets any material from production it gives us a requisition that is recorded immediately.

A MEMBER:—It appears that the method employed by the Chandler Co. might be called the pull-type rather than the push-type. Instead of having a large force ordering the material and watching it go through the factory, you make the persons who want the material interested in it, and have them pull it through, which often works to better advantage than pushing.

MR. BROWN:—Quite so.

A MEMBER:—You said incidentally that you store in stockrooms the parts that are likely to be stolen. We find that parts are not stolen from the stockrooms, but from the lines.

W. L. CARVER:—This system is based on line operation in every point, is it not? Every machine, in other words, is a line set-up that is not changed. You have no intermittent set-ups in the shop?

MR. BROWN:—Certain operations are so minor that one machine is employed to perform more than one operation; the amount of material on hand determines the time to make the change in the set-up.

MR. CARVER:—If a foreman has been using a certain machine for half a dozen parts, how would it work out?

MR. BROWN:—He would have to use his own judgment. If he sees that he cannot run any one of those parts through to completion, it will be necessary for him to make a change in the set-up.

CHAIRMAN HERRMANN:—Are stock-chasers assigned to certain groups of parts to take care of that contingency?

MR. BROWN:—By that particular grouping, I meant that all the parts that were bought from certain vendors were grouped; naturally, that would produce a certain classification of parts such as castings, forgings, accessories and the like. Materials are classified according to the vendors. A certain number of vendors is assigned to each man, and part of his follow-up work is to see that those particular firms are delivering material that is in accord with the specifications.

MR. CARVER:—In other words, you have outside stock-chasers rather than internal pushers?

MR. BROWN:—All the stock-clerks and the foremen naturally become stock-chasers on the inside because they want the material; and they do not give us any rest until they get what they want. But the stock-chasers are members of the follow-up section of the purchasing department and have outside connections only.

HOT-SWAGING OF REAR-AXLE SHAFTS

BY R. A. DE Vlieg²

AN intensive study of all the difficulties of hot-swaging axle-shafts by machine resulted in the conclusions that this method would be most economical and satisfactory if the maintenance costs due to the machines were held within suitable limits by improving their design and construction. Rolling, forging with steam hammers and turning were the three other methods considered, but laboratory tests show that swaging has improved the physical properties of this company's axle-shafts at least 15 per cent.

Following an illustrated description of the machines used and their mode of operation, difficulties attendant upon their development are recited. Among these, the failure of an air-operated collet to hold the bar against

the twisting strain necessitated its replacement by a special quick-acting chuck having high-speed-steel inserts in its jaws. The braking mechanism for slowing-down the head was inadequate and additional braking-capacity was provided by using a copper-lined brake-band. Careful application of this brake is necessary to avoid excessive twisting of the hot axle-shaft, but the tendency to twist the shaft was reduced by providing an exact amount of clearance in the dies and shimming them with plates of varying thickness. Rapid wear of the outer bushing and the rollers in the head was overcome by filling the head with lubricating grease and changing it frequently; the front bearing also was lubricated with grease.

Swaging machines should be considered as forging machines rather than as machine tools and given more

² M.S.A.E.—Tool engineer, Maxwell Motor Corporation, Detroit.

frequent attention and adjustment than the latter receive. Excessive twisting due to overheating of the stock or to operative carelessness in applying the brake to the head, often reaching one to three turns in the over-all length of a shaft, does not reduce appreciably the elastic-limit or the tensile-strength of the shaft as proved by laboratory tests. [Printed in the May, 1924, issue of THE JOURNAL.]

THE DISCUSSION

CHAIRMAN EUGENE BOUTON:—Have you experienced any trouble with scaling?

R. A. DE Vlieg:—That is controlled largely by the furnace. The scale in the first operation seems to be thrown off entirely before the work enters the dies. In disposing of the scale, however, the scale gets into the mechanism in the machine and, of course, causes much trouble. On the completed shaft, we do not have an unusual amount of scale.

B. B. BACHMAN:—It was not altogether clear to me from the paper as to just what form of shaft was used. I presume it was a semi-floating axle with an enlarged seat under the bearing at the outer end of the axle. What was the form of the bar upon which you started operations and what machine operations followed the swaging operation? How nearly complete is the shaft, and what state is it in when it comes through the swaging operation?

MR. DE Vlieg:—In our case the shaft is finished only on the spline end, the taper end and on the seat for the bearing. Other than that there is no finish. The operations, as illustrated and described in Fig. 4 of my paper, make the point more clear. The bar when we begin is some 8 in. shorter than the finished shaft. In the swaging process it is drawn out into the shapes shown.

MR. BACHMAN:—I presume the shaft is finally heat-treated after this operation?

MR. DE Vlieg:—Yes. It is cut to length. There is a little variation. If there is any variation in the diameter of the stock, we take it off the end. We allow about $\frac{3}{4}$ in. That is the only waste in material. We provide for that and cut all shafts to uniform lengths.

C. H. TAYLOR:—How many heats do you use in completing the three operations?

MR. DE Vlieg:—One heat for each operation, but the loss of heat between the first and the second operations is very little. The bar is heated throughout its entire length in the first operation, is still cherry-red as it leaves the first operation and is reheated in the second operation.

CHAIRMAN BOUTON:—What is the relative length of the bar before and after swaging?

MR. DE Vlieg:—The bar is 8 in. shorter than the finished shaft.

MR. TAYLOR:—At what temperature do you begin the swaging process?

MR. DE Vlieg:—The regular forging heat; I think about 1800 or 2000 deg. fahr.

MR. TAYLOR:—Is any machining done after the heat-treatment?

MR. DE Vlieg:—No. The shaft is heat-treated before any machining operation. Some time ago our engineering department was worried about the excessive twisting of the shafts, so we took a shaft that showed six complete turns in its length and sent it to the laboratory; it was about as good a shaft as we ever made in point of strength.

A MEMBER:—The twisting may have had a beneficial effect for the same reason that the old twisted Dunbar axle used to be considered about the best we could get.

MR. DE Vlieg:—Discussion was had in our own organization about that point. Some advanced the theory that if the twist were in the direction of the shaft it would be beneficial, but if it should happen to be in the reverse direction it might unwind and be detrimental. In making tests we have twisted the shafts both ways and have not found any reduction in strength.

W. L. CARVER:—Were the shafts tested for both torsional and tensile-strength?

MR. DE Vlieg:—They were tested for torsional strength.

QUESTION:—Is that a straight-carbon or an alloy steel?

MR. DE Vlieg:—An alloy-steel.

SYSTEMATIC GAGE-CHECKING AS A REQUISITE OF PRECISE MEASUREMENT

BY JOSEPH LANNEN^{*}

DUE to an increasing number of arguments and a constantly increasing volume of scrapped and salvaged material on account of the use of faulty gages, the company with which the author is associated was led to adopt a systematic gage-checking system and to install a separate gage-checking department. This was occasioned also by the growth of the business from one that produced a comparatively few cars into one capable of turning out 300 cars daily. During this growth the company experienced all phases of the gage-checking problem.

Details are given of the methods employed in creating and maintaining a gage-checking system, and a statement is made in reference to the equipment used and the good results that have been attained. [Printed in the April, 1924, issue of THE JOURNAL.]

^{*} Tool and equipment engineer, Paige-Detroit Motor Car Co., Detroit.

THE DISCUSSION

QUESTION:—What is the method of returning the gages to the crib? I imagine you have a central location. Are they handed in at certain intervals for inspection?

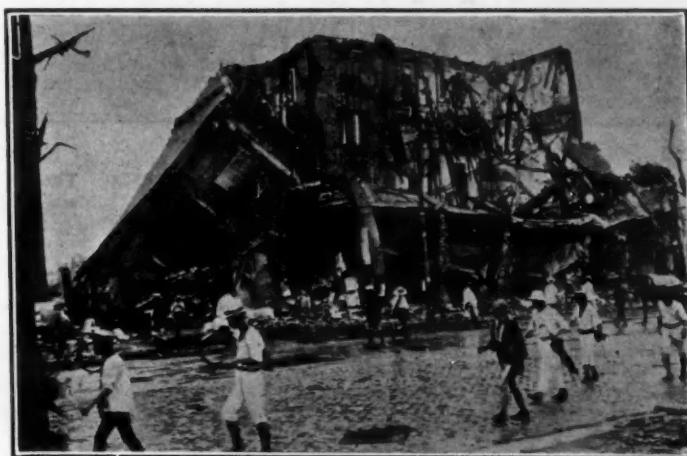
JOSEPH LANNEN:—The gage-checker takes a certain number of the cars that have been made out on the different gages and goes through the plant. He takes in a certain portion of the plant each day, checking the gages on the job. It is the duty of the gage-checking department to see that the gages are up to size and that they stay on the job. If any doubt exists as to the accuracy of a gage, the operator gets an order from his foreman to go to the gage-checking crib to have the gage checked. The reason for this order is that it is about the only way we can keep "the army" away from the place.

The Japanese Earthquake

SO far as is known none of the members of the Society residing in Japan lost their lives in the earthquake that visited the cities of Tokio and Yokohama last fall. The members will undoubtedly be interested in the letter written by Katsuharu Hibi, research fellow of the Institute of Chemical and Physical Research, and engineer of the Mitsui Mining Co., both of Tokio, under date of April 4 relating his experience, that is reproduced below. Some idea of the damage about the city of Tokio can be gathered from the accompanying illustrations.

I was so fortunate that I could get very narrow escape from last disaster in Tokio. When I was talking with the cheaf of the patent library in Tokio, suddenly we felt strong vertical earth quake which can not be considred trifle matter. After a few moment I found out that the windows were so severely shakend that they turnd out to show rhombic form and when I remind that the office is very old poor wooden building, I ran away from the room. Just when I reached to the entrance, some part of the roof was broken and fell down on my body completely covering some area. One parson who was only one foot distance from my position was killed at once while I was utterly fainted so that I have no memory at that very moment. After a while some one found out the dead one and at the same time finding I was also under the mass of the broken roof, he dragged me out when I began gradually recover myself. I was wounded on my face and hands and my white summer clothing was full of dirt mixed with blood.

It shaked incesantly with some interval which became gradually longer and longer. Every one was so confused that it took rather long time to arrange to



ANOTHER ILLUSTRATION OF THE DAMAGE CAUSED BY THE EARTHQUAKE
This Building Was the Maruzen, the Largest Bookstore in Tokio

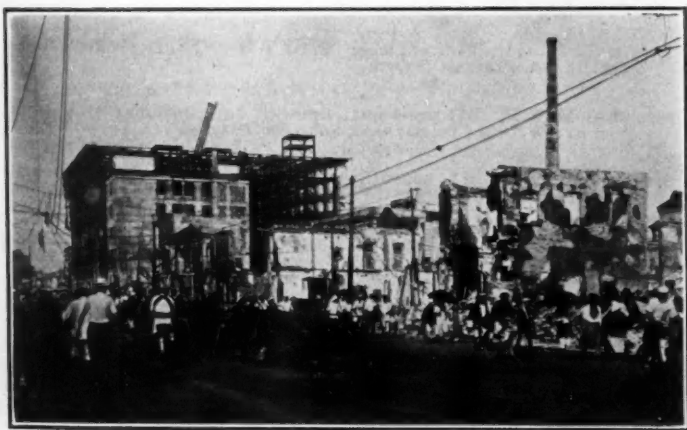
take me to a hospital by a motor car. That hospital was full of wounded person and the hospital building was still shakened to be very dangerous as it was broken to some degree. Doctors and nurses were brave enough to be very busy to treat the wounded ones. They looked never know that the terrible earth quake actually taking place. When I left the hospital, the street was full of crowd and broken part of the houses, of course I could not find out the motor car puzzling how to manage to go back to my house which is about 3 miles far away. It was really misterious that I could found out a Rikisha man in such confused crowd who accepted my offer to carry me to my house.

Every street was full of escaped ones, no tram car moved, motor car was hardly possible to be driven in such a crowd. Fire was to be found in several directions and my Rikisha man was very difficult to select the way where the least danger of fire was to be guaranteed. Railway of tram car was fully occupied by the inhavitants because this is the safest place as it is situated in the middle of the street and hard stones are laid between the rails.

My house is situated on the highest point of Tokio Where the ground is very rigid so that very trifle damage was to be found. My whole family was quite safe and was in the garden as it was quite adventurous to remain in the house when it shaked incesantly. WE slept in the garden during a few days. It was very fortunate that it was in summer and we could slept outside with the least danger.

Thanks to heaven, I am very glad to inform you that I am now quite healthy having no trace of damage caused by the earth quake.

Mr. K. Fujita and Mr. M. Negishi who are the member of the society may be safe though I have not the oppotunity to see them.



A PORTION OF THE CITY OF TOKIO AFTER THE EARTHQUAKE
The Steel Framework of the Building in the Background Should Be Noted in Contrast to the Smaller Buildings at the Right. The Mass of Metal in the Foreground Is the Ruins of a Trolley Car



Applicants Qualified

The following applicants have qualified for admission to the Society between May 10, and June 10, 1924. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

BALL, HAROLD APPLETON (J) draftsman, Autocar Co., Ardmore, Pa., (mail) 6446 Overbrook Avenue, *Overbrook, Pa.*

BARNARD, JOHN HALL (M) Engineers Club, 32 West 40th Street, *New York City.*

BIRKIN, K. W. (A) superintendent of motor vehicles, Sinclair Refining Co., 45 Nassau Street, *New York City.*

BLAKE, H. C. (M) manager, Foos Gas Engine Co., *Springfield, Ohio.*

BOCK, GEORGE E. (E S) student, mechanical engineering department, Engineering School, Columbia University, 117th Street and Broadway, *New York City.*

BOWMAN, EARL RAYMOND (E S) student, Tri-State College, Angola, Ind., (mail) 5760 North Sixth Street, *Philadelphia.*

BROOKS, MELVIN S. (A) sales department, Ford Motor Co. of Canada, Ltd., *Ford, Ont., Canada.*

CHATER, JOHN A. (M) engineer, Elite Mfg. Co., *Ashland, Ohio,* (mail) 414 Pleasant Street.

CLEMENS, H. E. (M) general superintendent, Motor Transit Co., 220 East Market Street, *Los Angeles.*

CROOKSTON, JAMES J. (J) cadet engineer, Waukesha Motor Co., *Waukesha, Wis.,* (mail) 427 Wisconsin Avenue.

DUNLEVY, LORIMER (A) works manager, Climax Engineering Co., *Clinton, Iowa,* (mail) 721 Douglas Court.

DUST, JOHN C. (A) superintendent of shops, Peerless Motor Car Co. of Illinois, *Chicago,* (mail) 5956 Union Avenue.

FLAHERTY, EDMUND M. (M) director of sales, E. I. du Pont de Nemours & Co., *Parlin, N. J.*

FRAUENTHAL, A. H. (J) chief inspector, Chandler Motor Car Co., East 131st Street and St. Clair Avenue, *Cleveland.*

GIBB, WILLIAM E. (A) sales manager, Joseph Van Blerck Engine Corporation, *Plainfield, N. J.,* (mail) 138 East Sixth Street.

HURLEY, FRANK EDWARD, JR. (E S) partner, Hempstead Blue Print Co., 125 Jackson Street, *Hempstead, N. Y.*

KYRIAKIDES, HARRY B. (E S) student, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., (mail) 36 South William Street, *New York City.*

LA FEHR, F. EDWARD (M) general service manager, Guy A. Willey Motor Co., *Philadelphia,* (mail) 30 South Fallon Street.

LANDIS, ROBERT B. (J) electric test man, Autocar Co., Ardmore, Pa., (mail) 509 Yale Avenue, *Swarthmore, Pa.*

LEAMON, WILLIAM G. (J) consulting engineer, 30 Linden Avenue, *Newark, Ohio.*

LOEFFLER, FRITZ (M) consulting engineer, 46 West 40th Street, *New York City.*

MADILL, GEORGE J. (A) owner, Motor Car Electric Service, *Highland Park, Ill.*

MARTIN, WALTER H. (E S) student, Stevens Institute of Technology, Hoboken, N. J., (mail) 18 Claremont Avenue, *Mount Vernon, N. Y.*

MEACHEM, T. G. (A) president, Meachem Gear Corporation, *Syracuse, N. Y.,* (mail) 411 Canal Street.

MONIHAN, JOHN GUY (A) special representative, Newport News Shipbuilding & Dry Dock Co., 9-235 General Motors Building, *Detroit.*

NADIN, THOMAS (M) engineer, Rolls-Royce of America, Inc., *Springfield, Mass.,* (mail) 31 Thompson Street.

O'HAIRE, P. J. (A) foreman machinist, Harrolds Motor Car Co., Long Island City, N. Y., (mail) 200 West 80th Street, *New York City.*

OWENS, H. THURSTON, (A) consulting engineer, National Gauge & Equipment Co., 51 East 42nd Street, *New York City.*

PALMER, LOUIS HOOKER (A) vice-president and general manager, United Railways & Electric Co. of Baltimore, 1005 Continental Building, *Baltimore, Md.*

PATZIG, CURT H. M. (A) mechanical draftsman, Bear Tractors, Inc., New York City, (mail) P. O. Box 242, *Cresskill, Bergen Co. N. J.*

PIKE, JAY R. (E S) student, University of Minnesota, *Minneapolis,* (mail) 1617 West Franklin Avenue.

RASCH, WILLIAM W. (E S) student, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., (mail) 1019 East 179th Street, *New York City.*

RHEIN, L. R. (M) body engineer, Ford Motor Co., *Dearborn, Mich.,* (mail) 19 Frances Avenue.

ROBBINS, AZOR D. (M) assistant engineer, International Motor Co., *New York City,* (mail) 144 Seaman Avenue.

SECOR, JOHN, A. (M) consulting engineer, Advance-Rumley Co., *LaPorte, Ind.,* (mail) 1108 Indiana Avenue.

SHANK, JOHN A. (A) service manager, Electric Auto-Lite Co., *Toledo, Ohio.*

SIPPEL, THEODORE E. (E S) student, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., (mail) 367 Wilson Avenue.

SPEIR, GODFREY B. (J) engineer, automobile department, Vacuum Oil Co., New York City, (mail) 435 Fairmount Avenue, *Jersey City, N. J.*

SPOONER, CLARENCE ROY (J) Eaton Axle & Spring Co., *Cleveland,* (mail) 2259 East 76th Street.

VAWTER, GEORGE W. (A) general sales manager, Capitol Overland Co., *Indianapolis,* (mail) 1065 Pomander Place.



APPLICANTS FOR MEMBERSHIP

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Applicants for Membership

The applications for membership received between May 15 and June 14, 1924, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ANDERSON, IVAN, mechanical aeronautical engineer, 809 Eighth Avenue, *Long Island City, N. Y.*

ARLINGHAUS, FRANK H., student, Stevens Institute of Technology, *Hoboken, N. J.*

BAJAC, ROBERT DE CASTEL, draftsman, 318 West 57th Street, *New York City.*

BAKER, MERRILL G., vice-president, Vanadium Corporation of America, *New York City.*

BEAVER, R. E., engineer and superintendent, Kearns-Dughie Motors Co., *Danville, Pa.*

BENDER, BERLIN, aviation engine mechanic, Bureau of Standards, *City of Washington.*

BERNHARDT, LEROY F., student, Rensselaer Polytechnic Institute, *Troy, N. Y.*

BRANNIGAN, JOHN F., draftsman, J. G. Brill Co., *Philadelphia.*

BRUCE, CLARENCE S., aviation mechanic, Bureau of Standards, *City of Washington.*

BUNYAN, GEORGE ARTHUR, student, Cornell University, *Ithaca, N. Y.*

BURR, F. H., director automotive division, Cleveland Pneumatic Tool Co., *Cleveland.*

BUTLER, HARRY A., superintendent, Autocar Co., *Ardmore, Pa.*

CAMPBELL, CAPT. ALAN L., office of the Adjutant General, *Fort Sill, Okla.*

CARLOS, MENELEO G., student, Cornell University, *Ithaca, N. Y.*

CARPENTER, JOSEPH G., sales manager, Merchant & Evans Co., *Philadelphia.*

CHAMPION, E. M., general factory manager, American Motor Body Corporation, *Detroit.*

CHITTENDEN, LORENZ P., district manager, Wire Wheel Corporation of America, *Buffalo.*

DAVIS, WALTER F., engineer, Wright Aeronautical Corporation, *Paterson, N. J.*

DENHAM, ATHEL FREDRIC, *Northport, N. Y.*

DOLLINGER, L. L., president and engineer, Staynew Filter Corporation, *Rochester, N. Y.*

DUNLAP, JAMES P., student, Armour Institute of Technology, *Chicago.*

DUSEVOIR, JULIUS, engineer, Star Motor Co., *Oakland, Cal.*

DYSTERUD, OLAF F., service manager, Nelson & LeMoon, *Chicago.*

EISINGER, JOHN O., assistant mechanical engineer, Bureau of Standards, *City of Washington.*

EMERY, HOWARD, manager, permanent mold department, Charles B. Bohn Foundry Co., *Detroit.*

EMERY, JAMES ALBERT, vice-president, Ford, Bacon & Davis, Inc., *New York City.*

FAWICK, THOMAS L., president, Twin Disc Clutch Co., *Racine, Wis.*

FLADER, FREDRIC, assistant aeronautical engineer, engineering division, Air Service, McCook Field, *Dayton, Ohio.*

FLEMMING, A. G., service manager, Hudson Motor Car Co., *Detroit.*

FORD, A. A., superintendent of equipment, California Highway Commission, *Redding, Cal.*

FRUEHAUF, HARVEY C., vice-president and general manager, Fruehauf Trailer Co., *Detroit.*

GEHRE, THURE GERHARD, draftsman, Fifth Avenue Coach Co., *New York City.*

GRABOSKI, LEO D., mechanical engineer, Vulcan Iron Works, *Wilkes-Barre, Pa.*

HENNECKE, EARLE V., vice-president and general manager, Motor Meter Co., Inc., *Long Island City, N. Y.*

HODGKINSON, ARTHUR, secretary and superintendent, New Haven Machine Co., *New Haven, Conn.*

HODGKINSON, WALTER, treasurer and manager, New Haven Machine Co., *New Haven, Conn.*

HODTUM, CLARENCE W., dynamic research, General Motors Research Corporation, *Dayton, Ohio.*

HOLMES, HAROLD W., president and general manager, Detroit Machine Tool Co., *Detroit.*

HOMAN, C. C., secretary, treasurer and general manager, C. G. Spring & Bumper Co. of Illinois, *Chicago.*

HURD, RODNEY SETH, special agent, Pennsylvania Railroad Co., *Philadelphia.*

JACK, DANIEL, superintendent and service manager, du Pont Motors, Inc., *Moore, Pa.*

KENNEDY, PAUL S., technical director, Murphy Varnish Co., *Newark, N. J.*

KNOOP, OSKAR, director of engineering, Nationale Automobil Gesellschaft, *Berlin, Oberschoneeweide, Germany.*

KRISTENSEN, N. Y., sales manager, C. G. Spring & Bumper Co. of Illinois, *Chicago.*

KYBURZ, WALTER W., student, Tri-State College, *Angola, Ind.*

LEROY, CLAUDE ARTHUR, student, Cornell University, *Ithaca, N. Y.*

LINN, HOLMAN H., vice-president and chief engineer, Linn Mfg. Corporation, *Morris, N. Y.*

LOWE, EDWARD F., general manager, K. P. Products Co., *New York City.*

LYON, FIRST-LIEUT. A. J., Air Service, McCook Field, *Dayton, Ohio.*

LYONS, L. E., Western sales manager, Spicer Mfg. Corporation and Sheldon Axle & Spring Co., *Detroit.*

MCALLISTER, A. J., general engineer, Fairfield Mfg. Co., *Lafayette, Ind.*

MANLEY, ROBERT EARLY, president and engineer, Manley Mfg. Co., *York, Pa.*

- MARTIN, WALTER H., student, Stevens Institute of Technology, Hoboken, N. J.
- MASCUCH, JOSEPH J., vice-president and general manager, Cox Corporation, Wilkes-Barre, Pa.
- MEZA, R. ROBERT, designing engineer and managing director, Peerless Auto Body Co., San Diego, Cal.
- MILLER, GLEN IRA, aeronautical engineer, Barnhart Aircraft Co., Inc., Pasadena, Cal.
- MILLER, H. K., student, Tri-State College, Angola, Ind.
- MILLER, ROSEWELL, instructor, New York University, New York City.
- MINCH, WALTER E., works manager, Jaxon steel products division, General Motors Corporation, Jackson, Mich.
- MORRISON, JOE W., patent solicitor, General Motors Corporation, Dayton, Ohio.
- MOTION, JOHN, superintendent, lubricant and graphite department, Joseph Dixon Crucible Co., Jersey City, N. J.
- OELKERS, A. H., chief mechanical engineer, St. Louis San Francisco Railway Co., Springfield, Mo.
- OHSAWA, GEN., works engineer, Buick Motor Co., Flint, Mich.
- PAGE, ERNEST, draftsman, Dot Motors, Ltd., Manchester, England.
- PARKHURST, ALLING, manager, Commercial Truck Co., New York City.
- PAUL, WILLIAM H., student, Oregon Agricultural College, Corvallis, Ore.
- PETERS, WILLIAM C., manager of sales and engineer, National Railway Appliances Co., New York City.
- RADLER, J. C., consulting engineer, Oakland, Cal.
- RAGAN, FRED H., factory manager, Columbia Axle Co., Cleveland.
- RASCH, WILLIAM W., student, Columbia University, New York City; evening course, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.
- RICHARDSON, CHARLES EDWARD, draftsman, Kitchener, Ont., Canada.
- RIEGER, NELSON, assistant engineer, Peerless Paper Co., Dayton, Ohio.
- ROGNON, RALPH C., president, Rognon & Co., Inc., New York City.
- SAFFOLD, J. WEBB, manager and chief designer, Devices Development Co., Cleveland.
- SCHUBERT, PAUL R., service manager, Kleiber Motor Truck Co., San Francisco.
- SEWARD, C. D., assistant manager of pricing department, International Motor Co., New York City.
- SHERIDAN, JOHN J., service manager, Rolls-Royce of America, Inc., Los Angeles, Cal.
- SIPPEL, THEODORE E., student, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.
- SMITH, CAPT. EDWIN A., Tank School, Camp Meade, Md.
- SMITH, HERBERT, sales manager, Manley Mfg. Co., York, Pa.
- SMITH, MILTON, JR., assistant general passenger agent, Louisville & Nashville R. R. Co., Louisville, Ky.
- SMITH, WELLESLEY M., garage shop foreman, Thompson Auto Co., Windsor, Ont., Canada.
- SPILL, CHARLES J., mechanical engineer, A. Schrader's Sons, Inc., Brooklyn, N. Y.
- STEWART, C. D., district engineer, Westinghouse Airbrake Co., Wilmerding, Pa.
- STRATFORD, JOHN PAUL, student, Cornell University, Ithaca, N. Y.
- STRONG, HERBERT T., vice-president, William Wiese & Co., New York City.
- TERR, JOSEPH, secretary, Selker Brass Mfg. Co., Cleveland.
- UNDERHILL, HAROLD, draftsman, Commer Motor Truck Co., Ypsilanti, Mich.
- VOSS, W. O., superintendent gas engine division, Hercules Corporation, Evansville, Ind.
- WATERBURY, W. E., superintendent, Timken Detroit Axle Co., Detroit.
- WESTCOTT, H. A., student engineer, Remy electric division of General Motors Corporation, Anderson, Ind.
- WILLS, JAMES, machine design draftsman, 1122 54th Street, Brooklyn, N. Y.
- WILSON, J. ALEXANDER, manager, pyroxylin division, Beckwith-Chandler Co., Newark, N. J.
- WITTICK, EUGENE C., draftsman, Borg & Beck Co., Moline, Ill.
- WOODWORTH, FRANK A., supervising operation of automotive equipment of Cities Service Co., H. L. Doherty & Co., New York City.

